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June 1-14, 2020 · Volume 182 · Number 11

JESSE H. NEAL AWARDS Est. 1955 66 WINNER 2020 Winner

62 *LauncherOne's rocket engine burned briefly as the Boeing 747 carrier aircraft, Cosmic Girl, banked sharply away following vehicle release.*

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COVID-19 CRISIS

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ON THE COVER

As the U.S. Army moves forward with two new high-speed rotorcraft acquisition programs, its most elite aviators see a once-in-a-generation opportunity to replace their hand-me-down fleet, but it will not be easy getting there. Defense Editor Steve Trimble's report begins on page 28. U.S. Army photo.

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FEEDBACK

BLUE ORIGIN

FORWARD-LOOKING DESIGN

Randy McDonnell's letter "Revising Rockets" *(May 4-17, p. 5)* presents a mix of good ideas and misunderstanding. My comments about it below are informed by my work as the government chief engineer on the DC-X technology demonstrator (for the Strategic Defense Initiative Organization) and as a consultant to NASA on the DC-XA.

First, I will address the idea of eliminating landing gear. The descending vehicle has been investigated in some depth in the years since the DC-XA, and while it could be made to work, it really emerges as an impractical solution. The issues would take too long to discuss here, but in the end, it is not a good idea. Using the rocket body as a decelerator is basically what most concepts use, whether it rotates or not. Multiple rebounds off the atmosphere is essentially the skip reentry technique, the concept of which goes back to Eugen Sanger. It has been used extensively on many missions such as Zond, Apollo, etc. It is more useful for entry range extension than reducing heating, but it does help to some extent.

The remaining ideas are very good and deserve more attention. Keeping the crew capsule integrated with the rocket to avoid excessive refurbishment and checkout activity between flights is essential to achieving rapid turnaround and minimizing operating cost. When an airliner flying from New York to Los Angeles arrives, you don't separate the passenger cabin and land it by parachute. It makes no more sense for a space transport than it does for an atmospheric transport.

Using aerodynamic control surfaces to control the vehicle during entry and landing is rational and has been well-demonstrated by SpaceX.

Rapid separation of the crew capsule from the rocket when the situation demands it is also essential. Even in that emergency case, there are better answers to achieve a safe landing than parachutes (the usual approach). We stand on the verge of developing real space transportation systems. Let's not screw it up with old-fashioned thought.

James R. French, Laguna Woods, California

BAD JUJU?

Too bad the folks at the UK's Defense Science and Technology Laboratory and the U.S. Air Force Research Laboratory threw out the acronym of their proposed new hypersonic round and simply gave it the unfortunate name "Thresher" *(April 6-19, p. 14)*. A little research reveals the USS Thresher (SSN-593) was a watershed loss for the U.S. Navy as the first nuclear submarine to be lost at sea, on April 10, 1963, 220 mi. off Boston in 8,400 ft of water. There may be some bad juju there.

Richard L. Hackmeister, Fort Lauderdale, Florida

REASONABLE, NOT RADICAL

I strongly disagree with letter writer Bob Seelos' position in "The Middle Seat" *(April 6-19, p. 6)* that airlines permanently stop seating passengers in middle seats and entire rows be removed. Such radical measures are entirely unnecessary.

Is it reasonable to place the threat of spreading COVID-19 or other future pathogens onto the airlines? Is it reasonable to bankrupt airlines by reducing passenger load factors to unprofitable and unsustainable levels? Is it wise to encourage government financial bailouts of airlines with the very real result of full or partial government ownership? I say "no" to all the above.

Instead, how about we adopt these policies: Encourage the public to wear masks voluntarily in public any time they are sick, as numerous countries have done in Asia for decades; require, or at least encourage, airline passengers to wear masks aboard flights, and require the airlines to provide them upon request at the terminal before boarding.

Reasonable solutions are better for everyone than radical solutions.

Kevin A. Capps, Corona del Mar, California

THE NEXT SWAN

Today the aerospace industry is reeling from the impact of COVID-19, as documented in the compendium of data in *AW&ST* and via your webinars associated with COVID-19 and its effects on aviation business and the supply chain. The presence of disease in the supply chain and manufacturing centers fits the definition of a black swan event, an event that was predictable but whose scope of impact was viewed as remote and so was not adequately addressed. We are now in the midst of recognizing that the impact, if not the disease itself, will likely last several years.

Now imagine a compounding event, a cyberbreach that manipulates our collective understanding of the state of the supply chain or software in the products we deliver. The actual state of the supply chain or software does not need to be altered to have an effect; merely altering the perception of them would affect projected parts availability, production rates, financial projections and stock prices, resulting in a skewed picture of the nation's ability to deliver operational defense and aerospace capabilities.

Similarly, a lack of confidence in the integrity of the software used to operate our military and industrial systems would have a parallel impact on both national defense and financial markets.

Instilling confidence in the integrity of critical data and software used in supply chains and operational aerospace systems is solvable. The aerospace community has the technical skills to mitigate the impact of a catastrophic black swan event so that it is just another swan in the flock of routine challenges.

David E. Hamilton, Jr., Alexandria, Virginia

CORRECTION

"Army Pushes Ahead With Black Hawk Replacement" *(March 23-April 5, p. 43)* should have stated that the difference between project agreement awards to the Sikorsky-Boeing and Bell teams is $13 million.

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

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WHO'S WHERE

Francois Lassale has been named acting CEO of *HeliOffshore*. He succeeds Gretchen Haskins, who will serve on the board. Lassale was chief operating officer.

York Space Systems has named **Barry Behnken** vice president of engineering. His career in space-systems development includes having been program director of the National Reconnaissance Office during his tenure in the Air Force, a Raytheon Technologies technical fellowship and co-founder of driverless car company AEye Inc.

Universal Avionics has promoted **Gil Rivnai** to vice president of engineering from head of engineering and **Marc Bouliane** to vice president of business development, marketing and services from vice president of business development. Rivnal succeeds Dan Reida, who has left.

Zachary Dunn has been hired as vice president of factory development for *Relativity Space*. Dunn was SpaceX senior vice president of production and launch

Ampaire has hired **Doug Shane** as general manager of aviation, with a focus on development of sustainable electric-powered air transport. An engineer and test pilot, Shane has overseen high-tech aerospace ventures for Scaled Composites and Virgin Galactic. He also won (with Burt Rutan and others, for SpaceShipOne) the 2004 Collier Trophy, an Iven C. Kincheloe Award and a Society of Experimental Test Pilots' James H. Doolittle Award.

Tim Williams has joined *Vertical Aerospace* as chief engineer. He was a chief engineer at Rolls-Royce.

Trine Aerospace has hired **Phuong Ta** as engineering manager. Phuong was certification lead at United Technologies and vice chair of the SAE International Aviation seat committee. She has served on FAA Aviation Rulemaking Advisory Committee working groups and is a structure and flammability designated engineering representative.

The Metropolitan Airports Commission (MAC) has hired **Tim Simon** as vice president of finance and revenue development. MAC owns and operates Minneapolis-St. Paul International and six general aviation airports in the Twin Cities area.

The Metropolitan Washington Airports Authority has promoted **Richard Golinowski** to vice president of operations for Reagan National and Dulles International airports. He has been with the Airports Authority for 25 years.

The White House has nominated former U.S. Congressman **John A. Culberson** to serve on the *National Space Council Users' Advisory Group*.

LinQuest Corp., a space systems technology provider for U.S. defense and intelligence, has appointed **Martin Faga** to its board. Faga was president and CEO of MITRE Corp. and has served on the boards of Alliant, Orbital ATK, DigitalGlobe and GeoEye. He also served as National Reconnaissance Office director, assistant secretary of the Air Force for space and as staff for the House Permanent Select Committee on Intelligence.

Triumph Group has elected **Richard Goglia** to its board and its audit and finance committees. He had been treasurer at Raytheon, which in April merged with United Technologies' aerospace and defense business to become Raytheon Technologies. Goglia previously was senior vice president at GE Capital.

Satellite connectivity provider *SES* has elected **Frank Esser** board chairman.

Paul Jarossy has been rehired as vice president of sales and marketing at *Vulcan Spring and Manufacturing*. He was Vulcan sales and marketing director in 2010-12 and held business development roles at Kaman Industrial Technologies and FlexLink Systems, among others.

Universal Avionics has hired **John Berizzi** and **John Wasmund** as South-Central and Southwest U.S. regional sales managers, respectively. Berizzi worked for Stevens Aviation and Boca Aircraft Maintenance, overseeing compliance installations and navigation upgrades. Wasmund worked at Hawker Beechcraft and Constant Aviation.

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.*

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FIRST TAKE

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TEXTRON AVIATION

GENERAL AVIATION

Textron Aviation's prototype Cessna Model 408 SkyCourier twin-turboprop utlity aircraft made its 2-hr. 15-min. first flight on May 17 from Wichita.

Piper Aircraft has received FAA type certification for its M600/SLS single-engine turboprop featuring Garmin International's emergency Autoland system.

MAGNIX

MagniX and AeroTEC flew a Cessna 208B Caravan converted to all-electric propulsion for the first time on May 28 from Moses Lake, Washington (page 48).

COMMERCIAL AVIATION

Previously profitable Latin American airline group LATAM Airlines became the latest high-profile victim of the COVID-19 crisis when it filed for Chapter 11 proceedings on May 26 in the U.S. (page 18).

The German government faces European Commission opposition to a €9 billion ($10 billion) rescue package for Lufthansa that would keep the airline out of insolvency while returning it as the largest shareholder with a 20% stake.

Mitsubishi Aircraft is mothballing its SpaceJet flight-testing operation in the U.S., consolidating operations in Nagoya, Japan, and closing all offices elsewhere.

A Russian government official has confirmed that COVID-19 restrictions have delayed certification of the Irkut MC-21 narrowbody commercial airliner beyond 2020.

Airlines globally have so far received more than $123 billion in government aid, but IATA warns the support is spread unevenly leading to massive market distortion in favor of richer economies (page 18).

The European Union Aviation Safety Agency has set out guidelines for flying in the COVID-19 era that include a requirement for passengers and crew to wear face masks at all times.

Changing the rules of the ICAO Carbon Offsetting and Reduction Scheme to reflect the impact of COVID-19 would risk undermining the entire program, says the Environmental Defense Fund lobbying group.

Air France has ended Airbus A380 operations, bringing forward an existing plan to phase out the superjumbo aircraft following the coronavirus outbreak.

Commercial aviation groups and manufacturers planned to file seven petitions challenging the Federal Communications Commission's decision to grant Ligado Networks access to spectrum near GPS (page 50).

DEFENSE

The U.S. Air Force's top general in Africa Command warned on May 26 that Russia's next move in Libya could be to deploy permanent, long-range air defense systems (page 39).

Leidos is to design and demonstrate the autonomy platform that will be integrated into and control the U.S. Air Force's future family of Skyborg unmanned aircraft systems.

The UK has begun firing trials of Thales' Lightweight Multirole Missile from the Leonardo AW159 Wildcat naval helicopter, ahead of the first deployment of the HMS Queen Elizabeth carrier task group in 2021.

VIEW FROM WASHINGTON

More Eyes on Those Troublesome Tankers

What a troubled program already in the congressional crosshairs does not want is more scrutiny from lawmakers. But that is where Boeing's KC-46A tanker for the U.S. Air Force finds itself.

Concerns about deficient and delayed KC-46As has spread beyond the Senate's defense-focused committees. Republican and Democratic members of a subcommittee of the Senate Committee on Homeland Security and Governmental Affairs have now called for an investigation into the program by the Government Accountability Office (GAO).

The committee members are seeking an assessment on the status of Boeing's planned fixes for critical deficiencies in the tanker, steps taken by U.S. Transportation Command to mitigate the operational effects caused by the delays and "considerations the Air Force is receiving because of the delays," the senators wrote.

The KC-46 program has been a key focus of the GAO's defense team since Boeing won the contract in 2011. The investigative arm of Congress has produced reports on the KC-46A annually since 2012 at the request of the Armed Services Committees of the Senate and House of Representatives.

The Air Force has accepted 30 KC-46As from Boeing, but Transportation Command refuses to use them until Boeing corrects the deficiencies.

NATO and European nations expressed regret at the decision from the administration of President Donald Trump to exit the Open Skies Treaty but said they share U.S. concerns about inconsistent flight restrictions imposed by Moscow (page 40).

A document published by the Italian Senate appears to confirm the €871 million ($965 million) sale of 24 Leonardo AW149 and eight AW189 twin-engine transport helicopters to Egypt.

The U.S. Tactical Boost Glide and the Hypersonic Air-breathing Weapon Concept hypersonic missile programs have fallen months behind schedule, says the head of the Pentagon's research and engineering branch.

Lockheed Martin now expects to deliver 18-24 fewer F-35s in 2020 than the program's 141-aircraft goal due to supply chain disruptions caused by the novel coronavirus pandemic (page 27).

Saab has signed a 1.55 billion krona ($160 million) contract with an undisclosed customer for its Erieye radar-equipped airborne early warning Saab 2000.

SPACE

NASA and SpaceX retargeted launch of the crewed Demo-2 flight test for May 30 after weather at Kennedy Space Center prompted a scrub 16 min. before a liftoff attempt on May 27 (page 52).

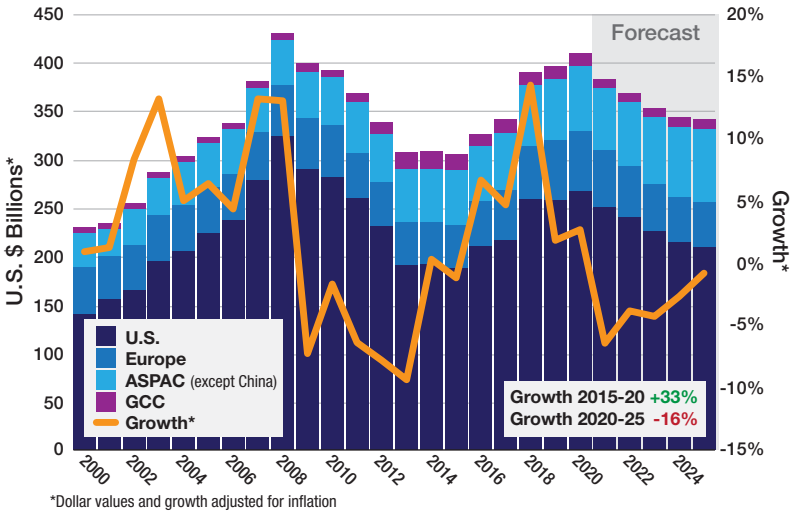
British satellite launcher firm Skyrora has undertaken a full static fire test of its Skylark L rocket, the first UK test of this scale since the Black Arrow program 50 years ago.

NASA has renamed its threatened Wide Field Infrared Survey Telescope the Nancy Grace Roman Space Telescope in honor of the pioneering woman astronomer.

High-speed propulsion developer Reaction Engines has been awarded a European Space Agency study contract for a hypersonic flying testbed for its Sabre air-breathing rocket engine.

A United Launch Alliance Atlas V rocket lifted off from Cape Canaveral AFS on May 17 to deliver a U.S. Air Force X-37B mini-shuttle into orbit for a sixth mission.

COVID-19 to Impact Global Defense Procurement



Source: Craig Caffrey, Senior Aerospace Industry Analyst, Aviation Week Network

Procurement and R&D will lead global defense spending cuts in the aftermath of the novel coronavirus pandemic, forecasts Craig Caffrey, senior aerospace industry analyst with the Aviation Week Network. Cuts will be disproportionately concentrated in key domestic and export markets of Western defense suppliers.

To request more information about Aviation Week's Military Fleet Discovery Database, go to **pgs.aviationweek.com/FleetDataServices**

75 YEARS AGO IN AVIATION WEEK

With memories of the ecstatic V-E Day celebrations still fresh, our June 1, 1945, edition reflected on key challenges that lay ahead for the U.S. and the aviation industry. A costly war in Europe had just been won, but the fight in the Pacific was still raging, with the bloody Battle of Okinawa still undecided. Meanwhile, a new American foe already appeared to be rising in the Soviet Union—still officially a U.S. ally.

The magazine's coverage included a technical review of a startling new form of aircraft propulsion called a turbojet, and an advertisement featuring Sikorsky's latest rotary-wing marvel, the R-6, adorned the cover. But the post-V-E Day reality was visible, too, with a cover appeal to buy war bonds signed by all seven five-star flag officers: Gens. George Marshall, Douglas MacArthur, Dwight Eisenhower and Hap Arnold joined by Adms. William Leahy, Ernest King and Chester Nimitz.

Publisher Harold McGraw, Jr. appealed for a repairing of relations with Moscow, lest the "defeat of Japan merely mark the end of the Second in a series of World Wars." And Editor Leslie Neville urged readers not to forget the lessons of recent defeats in battle. "It is easy for us, as survivors of this phase of the war, to don our own Superman cloaks and assume that we are unconquerable," he warned. "We must not relinquish our dominant air power until we are perfectly sure that it is safe to do so."

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

UP FRONT
REMZI SEKER

Aviation's Other Problem

It is time to **accelerate cybersecurity**

WITH THE EXPANSION ACROSS the aviation industry of connectivity and computing services, cybersecurity has become ever more important. Connecting people, processes and assets creates new vulnerabilities and multiple attack points—from flight-critical avionics to passenger inflight entertainment networks and airline backend operations. Information about systems, protocols and technologies such as software-defined radio are now readily available well beyond the industry. Demand for greater efficiency meanwhile continues to increase connectivity and accelerate computerization within aviation infrastructure, including aircraft.

CHAINARONG PRASERTTHAI/GETTY IMAGES

Fortunately, ongoing efforts to protect aircraft, airlines and passengers from cybersecurity threats have been largely unaffected by the global pandemic, suggesting an opportunity for the industry to ramp up cybersafety programs and training amid the current slowdown. The comprehensive, coordinated nature of aviation cybersecurity initiatives means committees have long carried out their work primarily through virtual meetings, so those efforts are able to continue in full swing. With slowdowns taking place in other areas, the industry can address cybersafety at a more rapid pace.

The aviation industry and its stakeholders have been working hard to tackle cybersecurity challenges comprehensively—from the supply chain and the maintenance of aircraft to operations. Such efforts remain essential so that cyberthreats affecting safety can be mitigated before they materialize, whether that happens during flight through physical access to a bus, by interfering with equipment through Wi-Fi or remotely disrupting operations.

The need to weigh cyberthreats according to their safety impact, a practice referred to as "cybersafety," requires a different perspective than that of IT cybersecurity. Cybersafety differs from traditional IT cybersecurity because of the need for safety certification, which relies on guaranteeing a system's behavior, or "determinism." This unique characteristic of aviation cybersafety means that solutions widely used across traditional computing systems may pose serious certification challenges. Imagine rolling out security patches for every avionics component on a commercial aircraft.

Tackling cybersafety challenges requires a coordinated, comprehensive, global effort. Multiple agencies are cooperating to establish much-needed standards. For example, the U.S. FAA and the European Union Aviation Safety Agency have been working with the RTCA and the European Organization for Civil Aviation Equipment to set harmonized cybersecurity standards.

Efforts to secure the aviation ecosystem also include dedicated committees such as the FAA's Aviation Rulemaking Advisory Committee Aircraft System Information Security/Protection working group. Similarly, the Aerospace Industries Association has established the Civil Aviation Cybersecurity Subcommittee.

In the U.S., the Aviation Cyber Initiative (ACI) is led by the Defense Department, Department of Homeland Security and FAA. The ACI includes experts representing government, defense, industry and academia who collaborate to tackle aviation cybersecurity threats. The Aviation Information Sharing and Analysis Center shares global threat intelligence among aviation companies.

Globally, the International Civil Aviation Organization (ICAO) leads this work. Its Trust Framework Study Group (TFSG) includes experts from the FAA, EASA, commercial industry and academia and has established three important working groups.

Academic institutions play a critical role in advancing cybersecurity research and training, too. Embry-Riddle Aeronautical University, for example, develops engineering solutions and provides degree, certification and training programs in aviation cybersecurity. Faculty researchers contribute expertise to cyberdefense and preparedness efforts by serving on national and international committees and working groups and by organizing the annual Aero-Cybersecurity Symposium.

Aviation's impeccable safety culture positions it well to combat and defeat cybersafety risks. In the years ahead, the industry will need to invest in expanded education and training as well as research to secure high-assurance systems that can be updated with minimal impact on certification.

Remzi Seker is the associate provost for research at Embry-Riddle Aeronautical University.

GOING CONCERNS
MICHAEL BRUNO

Top-Heavy

As manufacturing reshapes after the pandemic, **size will matter**

IF YOU LIKE THE CADRE OF BIG aerospace and defense companies now, you are going to love them later. Among the major trends the novel coronavirus is expected to catalyze within aerospace and defense (A&D) manufacturing is that the big will get bigger by gobbling up others or taking back more work.

In the next few years, vertical integration should pick up momentum, according to several executives and consultants. After decades of OEMs, primes and top-tier companies outsourcing major work on their programs, many see the pendulum swinging back to bringing more of it in-house.

"We've already seen signs of more vertical integration coming through the industry and potentially where some of that could be accelerated as we work through the crisis," says one advisor.

Boeing started this a few years ago as it insourced avionics and other niche segments. Major consolidation picked up last year with the mergers of Raytheon and United Technologies Corp. and L3 Technologies and Harris Corp. Now, whether it be protecting profits or securing supply, the reasons to own more of the work are burgeoning as industry is refashioned in the COVID-19 crisis.

As smaller suppliers fall away, who will pick up the pieces? The left example shows Tier 1 consolidation; the right, Tier 2-3.

For starters, aerospace suppliers are facing diminished economies of scale but a greater share of fixed-cost in production, with a likely loss in profitability and competitiveness, say Roland Berger advisors Robert Thomson and Manfred Hader. So-called organic top-line increases, through insourcing and acquisition of additional work packages, are possible but only to a limited degree. A fixed-cost reduction likewise is only feasible up to a certain level due to equipment and overhead structures. So consolidation is an important lever to consider.

Part and parcel to that will be the financial distress into which suppliers in Tier 2 and below fall—and the opportunity to roll them up.

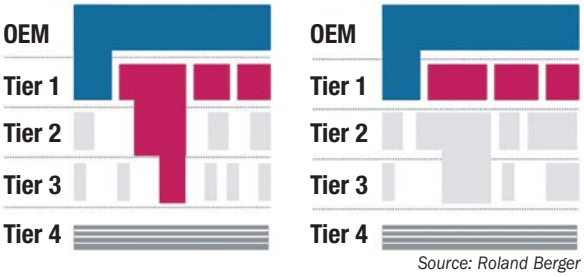
Top CEOs are watching. Speaking May 13 to an investor conference, Honeywell International Chairman, CEO and President Darius Adamczyk cited an inflection point. "For a couple of years now, I've been talking about how it is a seller's market, not a buyer's market," he told Goldman Sachs. "But that calculus may change in the second half of the year, and I think it could become a bit more of a buyer's market, and the valuations may be better and different. That's something that we want to partake in."

Feeding the phenomenon could be a desire to bring supply closer to home, both for reliability and geopolitical reasons. Suppliers overseas once were revered for their low-cost footprint, but suddenly they are seen as vulnerable to pandemics, economic stress and global trade wars. In turn, consultants expect industry leaders to take another look at favoring local regions.

Even in the defense realm, which for now is considered safer during this downturn, there is talk of larger firms becoming even more powerful. "Large pure-plays should come through the pandemic relatively unscathed but may be looking at lower spending growth outlooks," Capital Alpha Partners Managing Director Byron Callan noted May 13. "Mergers and acquisitions may thus be more important in delivering growth—even though it's not organic growth—in 2021-25."

So where to look for vertical integration and consolidation from the top? Clues are already emerging,

INDUSTRY CONSOLIDATION
Two Possible Evolutions



Source: Roland Berger

according to advisor presentations. First, look at niches where top suppliers already are prevalent—environmental and flight-control systems, landing gear, electrical power and interiors—and others where they are not there yet, including maintenance, repair and overhaul, logistics, aerostructures and engines.

Next, look at the supply base from the perspective of a top supplier. Who is distressed or drawing down credit lines? What revenue mix do certain potential targets have—e.g., commercial vs. defense, products vs. services or aging vs. next-generation platforms?

Finally, consider where the new nucleus of consolidation will be. Will more "super Tier 1s" such as Raytheon Technologies emerge, or will conglomeration occur among Tier 2 and 3 providers? The first would allow rationalization of capacity for detailed part production from Tier 1 to 3, for instance, with the super Tier 1s able to secure through-value-chain control and prevent subtier supplier failure, according to Roland Berger. The latter likely would be opportunistically driven rather than following any overarching industry logic.

For smaller suppliers, the questions are more concise, as one consultant says. Do you want to be a buyer, a seller or risk it as is? A simpler question, for sure, but no less difficult to answer.

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WILLIAM GARVEY

Perfect Pairing

The **right man at the right time** to save a piece of history

HE WAS PAGING THROUGH AN aviation history magazine when an article about Columbine II, President Dwight Eisenhower's aircraft and the first with the call sign Air Force One, caught his eye. He learned that the government had declared the four-engine Lockheed Constellation as surplus and, in 1970, sold it at auction to a private buyer—something never repeated with a former presidential aircraft.

And now the curvaceous, tri-tailed "Connie" was chocked and wilting under the desert sun in Marana, Arizona, and if it was not moved, it would possibly be scrapped. That was in early October 2014. He put the magazine down and returned his attention to Dynamic Aviation.

By way of background, the reader, Karl Stoltzfus, in 1967 co-founded what became Dynamic with his brother, Ken. Six years later, Ken went into the ministry. Meanwhile, Karl steadily grew the Bridgewater, Virginia, aerial-application operation with DC-3s and Beech 18s and even bought its home airport. Then in 1996, the unexpected occurred.

COLUMBINE II

The U.S. Army announced it was shedding its fleet of U-21 Utes (unpressurized King Air 90s) and asked for bids. Stoltzfus carefully weighed all aspects of the solicitation, did some calculations and, holding his breath, submitted a bid worth $9 million for all 124 aircraft. And his bid won. What happened subsequently is another story, albeit a positive one (*AW&ST* April 28, 2014, p. 16). The company today has some 700 employees, operates on several continents and counts the U.S. government among its most important customers.

Accordingly, the degeneration of what had once been a symbol of America's technological and global leadership troubled Stoltzfus, a serious student of history. He called the Connie's owner to discuss the situation, and the following week, his brother was on his way to assess the aircraft's condition.

Further background: Karl and Ken's father ran an aerial application business in Pennsylvania. As boys, the smell of avgas and the roar of round engines were constant. Their alternate schoolhouse was a hangar; their mentors, airplane mechanics. When the twin brothers were 23, their father bought five dilapidated DC-3s and sent his sons to fix and fly them home. They did. Karl has since restored a number of winged derelicts.

So Ken's scouting assignment was to determine if the Connie was cancerous with corrosion, for if so, Karl would have none of it. Ken's report back to Bridgewater: Little corrosion, but "Don't underestimate the work involved." Alas, Karl was to discover: "He was right."

The Connie's owner wanted to sell it to someone who would restore and preserve it and quickly recognized Stoltzfus as that someone. The two men settled on a price somewhat below the $1.5 million desired, and soon Dynamic maintenance crews were shuttling between Bridgewater and Marana. Laboring in torrid heat, their goal was to get the Connie ready for ferrying to Bridgewater for the full restoration.

On March 8, 2015, Stoltzfus flew a King Air to Marana to see his prize first-hand. During his slow, careful walkaround, his heart began to sink. The Connie was a sorry pile, and he realized that returning it to glory would be an overwhelming undertaking. When he came back the following day, however, he recalls the airplane seemed to scream at him: "This is something you're supposed to do!" And that, along with encouragement from aviation friends, was it.

On March 18, 2016, the city of Marana hosted an airport party with Mary Eisenhower, the 34th president's granddaughter, as guest speaker. The purpose was to bid farewell to Columbine II. The following day, the old Connie rumbled into the air for the first time in 13 years. The test flight revealed only minor squawks.

Finally, on March 23, an excited crowd gathered at Bridgewater Air Park to witness history. Soon, Columbine II roared into view and circled overhead. Despite a stiff crosswind, Lockie Christler, a veteran Connie and business jet pilot, settled the belching transport on the center of the narrow 2,745-ft.-long runway, rolling to a stop as onlookers waved and cheered.

Since then, 10-20 Dynamic technicians have been working daily to resurrect the aircraft. Stoltzfus is budgeting $1 million per year to the effort. Asked when that might conclude, he laughs: "I say, 'Three more years,' no matter when you ask me."

Dynamic plans to house the Connie in a new hangar dedicated to the Eisenhower legacy and will use it to support customers, inspire youngsters and occasionally display at airshows. Stoltzfus says he's thrilled to be "preserving a piece of American history."

Once finally restored, he says, "People are going to love this airplane."

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

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Postgraduate School of Flying: **ITPS Canada**

Experienced pilots and aerospace engineers aiming to take their careers to the next level need look no further than London, Canada.

The Southwestern Ontario city, just north of Lake Erie and the U.S. border, is home to one of the world's top training schools for military and civilian test pilots and flight test engineers: International Test Pilots School (ITPS). Expanding upon this solid foundation, the school recently added another dimension by launching the International Tactical Training Center (ITTC). It focuses on military mission-oriented training, including fighter lead-in training, mission commander, and fighter weapons and tactics courses. Together, the two divisions fall under parent company ITPS Canada.

Headquartered at the London International Airport (CYXU), ITPS Canada delivers both fixed- and rotary-wing training on a diverse fleet of 20 aircraft that includes 11 jet trainers, two transonic fighter trainers, a seaplane and a variety of helicopters.

ITPS teaches civilian and military pilots how to thoroughly quantify the flying qualities, cockpit workload, and performance envelope of new aircraft (or modifications to existing platforms) to ensure safe operations.

Students benefit from a unique combination of expert instructors, training aircraft and technology-based learning. Approved by international regulatory bodies including the European Union Aviation Safety Agency (EASA) as a flight test training organization for both fixed- and rotary-wing test pilots, ITPS produces graduates who are active worldwide in major national projects such as the new T-625 Turkish medium helicopter, the Airbus A-400, and the Turkish Hurkus.

The school has assembled a unique and diverse fleet of training aircraft, including the British Hawker Hunter T75, Aero Vodochody L-39C and L-29, Bombardier Challenger 601 and Embraer Phenom 100 and 300 models, as well as MBB BO-105M and Bell 206 helicopters, among others. ITPS President Giorgio Clementi said fleet diversity is essential to meeting customer needs and preparing graduates for their new roles.

"ITPS customers operate everything from light aircraft to business jets, civil airliners, military transports, high performance trainers and jet fighters," he explained.

In 2020, ITPS Canada opened a brand new 27,000-square-foot hangar and expanded its classroom facilities to 10,000 square feet. The new facility unites all training programs under one roof, allowing for what Clementi called "tremendous synergies" between civilian test pilots and fighter pilot instructors.

"It makes for an incredibly stimulating learning environment for the student and a very active flight organization," he said, adding that ITPS Canada harnesses new technologies to further enhance the student learning experience.

For example, the cockpits of its L-39 Albatros fleet have been upgraded with full-color touchscreen displays and hands-on throttle and stick controls. Simulation is heavily incorporated into all training programs, and the school employs virtual reality (VR) to boost training effectiveness.

"Two years ago, we introduced virtual reality elements into our avionics systems syllabus," said Clementi. The school used off-the-shelf hardware and commercial software to teach the evaluation

of helmet-mounted displays and synthetic vision systems, with excellent results.

"Technology is very important. We're busy forging ahead and we're doing some good work with VR, advanced simulators and certified sims from CAE. ITPS is leveraging simulation to expand its programs and capabilities."

ITPS Canada delivers customized training programs designed to meet the needs of its civilian and military customers, tailoring in-air instruction to the type of aircraft most relevant to a student's future work.

The school offers graduate, diploma and certificate courses for both civil and military pilots that range from three to 50 weeks in duration.

Its core product is the one-year Graduate Test Pilot and Lead Flight Test Engineer Course, fixed-wing or rotary, which is EASA CAT-1 compliant and recognized by the Society of Experimental Test Pilots and the Society of Flight Test Engineers. Comprised of about 500 lecture hours and more than 100 hours of flight training on a minimum of 15 aircraft types, this course thoroughly prepares students for the professional demands of a test pilot or flight test engineer career.

The school is able to take the training to the customer, having assisted with a helicopter certification program in China, aircraft modification testing with the Royal Thai Air Force, and military tactical training in Indonesia and Malaysia.

ITPS Canada is one of just eight accredited test pilot schools in the world – and one of only four approved by EASA. With its varied fleet, emphasis on technology and regulatory accreditations, the school is a solid choice for advanced pilot and engineer training.

Visit **www.itpscanada.com** for more information.

ONLY THE LUCKY SURVIVE

Jens Flottau Frankfurt, **Adrian Schofield** Auckland, **Bradley Perrett** Beijing and **Sean Broderick** and **Ben Goldstein** Washington

The airline industry, particularly in the U.S. and Europe, likes to complain that governments are not paying enough attention to its needs even in normal times, and that unfair burdens such as high taxes, onerous consumer protection rules or growing pressure from environmentalists hamper it.

But three months into the global spread of the novel coronavirus, the predicted mass airline failures have yet to materialize. Why? Largely because of the $123 billion that the allegedly uncooperative governments have pumped into the sector since March.

The money was instrumental in avoiding bankruptcy filings by the world's largest airline groups in the U.S. and Europe. The $52 billion Coronavirus Aid, Relief, and Economic Security (CARES) Act stabilized the U.S. industry, and only on May 25 did Lufthansa get its own €9 billion ($10 billion) package, preceded by a €7 billion deal for Air France-KLM some weeks earlier.

According to the International Air Transport Association (IATA), loans make up more than $50 billion of the overall support volume and are by far the most important type of measure, followed by wage subsidies ($34 billion), loan guarantees ($11.5 billion) and equity financing ($11.2 billion).

Almost regardless of who is providing the support, unless it is in the form of outright grants, airlines are going into the post-COVID-19 restart phase with very high levels of debt. Of the government packages alone, $67 billion involve new liabilities. But airlines raised a further $52 billion in cash from banks, investors and lessors. IATA expects debt levels to increase to $550 billion by year-end. IATA Chief Economist Brian Pearce says more airlines could fail under the weight of debt, or governments could become more involved as debt is converted into equity at a later stage.

Still, it cannot be said that governments are not acting. The trouble is they are mainly acting in selected rich, developed countries that can afford to support their industries. And even among the rich, there are huge discrepancies: While the U.S. was prepared to offer 32% of 2019 airline revenues, according to IATA statistics, Canadian airlines received only 1.3%.

In other large regions, airlines are

F-35 production slowdown **p. 27**

- GOVERNMENTS SPEND $123 BILLION ON AIRLINE RESCUES
- MEASURES HELP AVERT BIGGER WAVE OF BANKRUPTCIES
- AIRLINE SECTOR TO ENTER RECOVERY WITH HIGH DEBT BURDEN

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On May 26, LATAM Airlines became the latest high-profile commercial aviation victim of the coronavirus crisis.

getting very little or no assistance, either because governments decided it is bad policy to pump money into the sector or because they simply cannot afford to do so. Airlines in Latin America and parts of Africa are essentially on their own, though there are exceptions such as the Middle East and Persian Gulf, where states have stepped up. "There is very limited support in emerging markets," Pearce says. China, where the big three players are all state-owned as in the Middle East, is a whole different story.

Airlines everywhere have made "cash last longer," as Pearce puts it, by implementing major cost cuts, and the healthier ones that represent acceptable levels of risk to lenders have been able to raise cash from banks or private investors as well.

However, there is a correlation between the level of support and the likelihood of failure. Virgin Australia, arguably an airline in some level of difficulty before COVID-19 hit, filed for bankruptcy after the Australian government decided to not offer assistance. LATAM Airlines, however, the latest high-profile victim, was profitable before the crisis. It was by far the largest player in its region, supported by powerful investors such as Delta Air Lines and Qatar Airways and about to enter a joint venture with Delta, pending regulatory approval.

Still, LATAM filed for Chapter 11 proceedings May 26 at the U.S. Bankruptcy Court for the Southern District of New York.

"LATAM entered the COVID-19 pandemic as a healthy and profitable airline group, yet exceptional circumstances have led to a collapse in global demand and brought aviation and revenues to a virtual standstill," the company stated. "In light of the industry-wide collapse in demand and subsequent financial pressures caused by COVID-19, we need to take further action to ensure our airline group long-term sustainability." Affected by the filing are LATAM and its affiliates in Chile, Peru, Colombia, Ecuador and the U.S., but not subsidiaries in Brazil, Argentina and Paraguay "due to the nature of their debt structure and current financial status," the company said.

LATAM is now the second large Latin American airline to file for bankruptcy in May, following one of its largest rivals in the region, Avianca. LATAM is operating only around 5% of its normal schedule and has announced plans to cut 1,850 of 40,000 jobs in the group. According to court documents, leases for 19 aircraft are affected, including two Airbus A350s, one A319, one A320, 11 A321s and four Boeing 787-9s. Airbus and Boeing are also exposed in terms of orders: LATAM Airlines has outstanding orders for 20 Airbus A320neos, 19 A321neos and two A350-1000s, six Boeing 787-9s and one 777F. It already canceled orders for 10 A350s earlier this year.

Some of its shareholders have committed to financial support in the restructuring in the form of a loan. The financing is provided by the Cueto family, which took control of what was then LAN Airlines in 1994 and still is the largest shareholder of the broadened group (21.5%), the Amaro Group (representing the former owners of TAM Brasil) and Qatar Airways. Noticeably absent from the group is Delta Air Lines, which owns 20% of LATAM, a stake it acquired in September 2019 to ensure much better access to Latin America. Under the conditions of the CARES Act, U.S. airlines cannot provide financing to subsidiaries abroad.

LATAM left the Oneworld alliance on May 1. Delta and LATAM signed a joint-venture agreement covering flights between the U.S. and Latin America, onward connections and frequent-flyer benefits on May 7. LATAM Airlines Group was set up in 2012 as a result of the merger of LAN and TAM.

Boeing CEO David Calhoun said in a CNBC interview that the bankruptcy of a U.S. airline was "most likely" despite CARES funding, a comment that has not made him many new friends in the airline industry. And American Airlines CEO Doug Parker, for that matter, then felt he needed to step up and say that American will not need bankruptcy protection to get through the current downturn. The rest of the large U.S. carriers are in similar shape, he says.

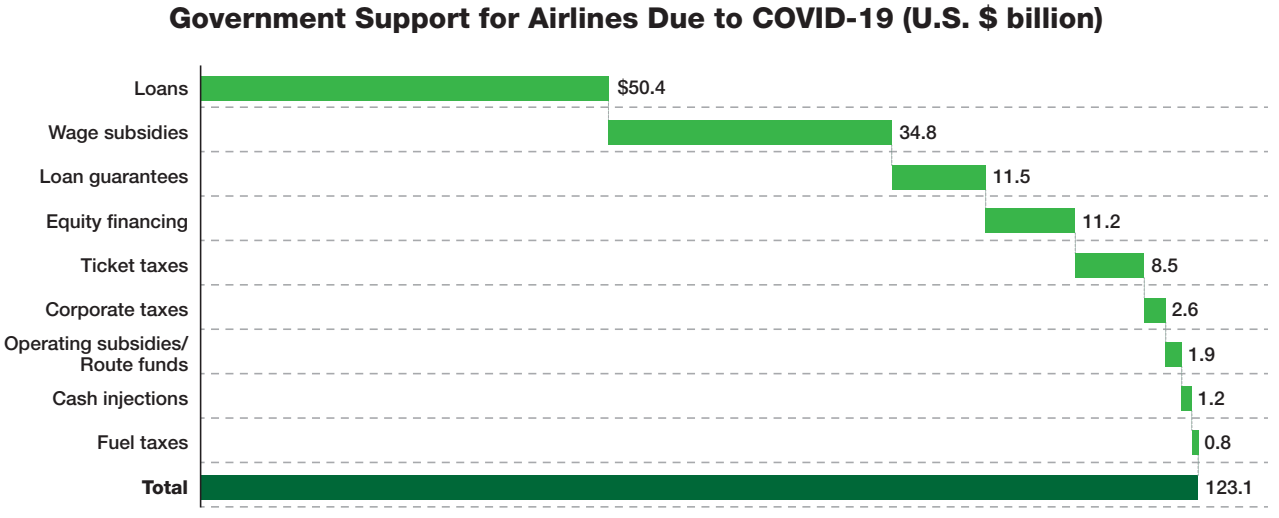
"I don't think people should view bankruptcy as a financial tool. I think it's failure, [and] we're not going to do that," Parker said during a Sanford Bernstein investor event May 27.

He added that U.S. airlines are facing a "demand crisis" caused by the novel coronavirus pandemic, which bankruptcy cannot help. That's different than unsustainable costs in an oversaturated environment. "There's no one trying to push anybody else out of business," Parker said. "It's all about demand. We need demand to come back.

"I think we're all going to be fine," he added. "I think we're all going to go raise enough liquidity to get ourselves through this wall."

Parker said American is "on track" to meet its goal of reducing daily cash burn to $50 million in June, adding that it will average $70 million for the quarter. The company expects to end the second quarter with $11 billion in liquidity, including both payroll-sustainment money and a $4.75 billion government-backed CARES Act loan that is not finalized.

A slight uptick in demand will help by adding much-needed revenue to the carrier's coffers. "I'm going to be



Source: IATA

really careful when we talk about this, because we are still flying only 20% of our schedule. But on that much-reduced schedule, we are definitely seeing more demand than we've seen in prior months," he said. American's April load factor was 15%, while the U.S. Memorial Day holiday weekend saw the average flight 56% full.

"These are early returns, but they are encouraging," Parker said. "This is much better than it was a few weeks ago, and it looks better as we look out into June."

Further out, barring a stunning about-face, American and every other airline locked into maintaining their payrolls to meet CARES Act funding requirements until Oct. 1 will have to get smaller—and fast. American's "goal" remains to shrink using voluntary processes, but Parker acknowledges that will be a challenge.

"We will need to make sure that we rightsize our company accordingly," he said. "We're going to try to do that in a way that, hopefully, we wouldn't even have to furlough anyone. I know that sounds like a stretch. It's a goal; it's not a commitment."

U.S. airline traffic bottomed out on April 14, when roughly 88,000 people passed through TSA checkpoints, compared to 2.2 million on the same day last year. Since then, there has been a steady uptick in traffic, with nearly 350,000 people tracked on May 22 ahead of the Memorial Day holiday, the highest daily total in months but still down 88% from a year ago.

Delta Chief Financial Officer Paul Jacobson said net sales have improved modestly, with some recent days of positive net bookings for the first time in months, citing increased demand for beach destinations in Florida and the West Coast. "We think this is really driven by an uptick in leisure bookings for domestic travel in June and July," Jacobson said May 19 on a Wolfe Research Group investor webcast.

United Airlines has also seen a reduction in customer cancellation rates accompanied by a "moderate improvement" in demand for domestic travel in recent weeks. And Southwest Airlines, now the country's largest carrier by seats offered, reported positive month-to-date net bookings through May 18.

Airlines are adding capacity in June in preparation for the anticipated upswing. Domestic carriers will operate the largest portions of their schedules, led by Southwest at 52% of last summer's levels. Alaska Airlines and JetBlue Airways will double their seats on offer in June from May, while ultra-low-cost carrier Spirit Airlines is bucking the trend with plans to operate just 5% of its 2019 schedule next month.

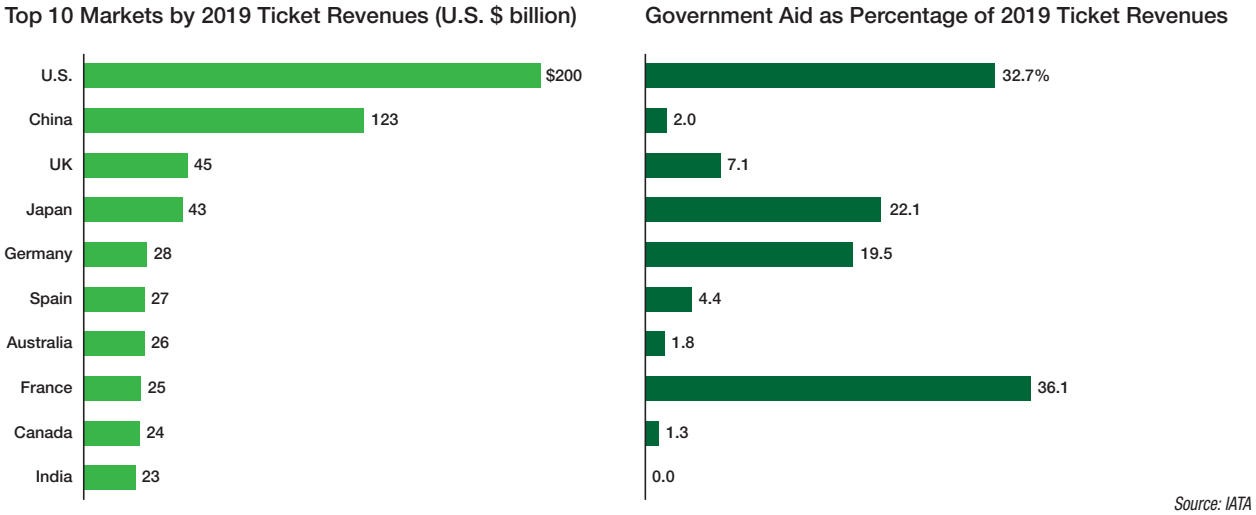
Full-service carriers, with far greater international exposure, are playing it slightly more conservatively. Delta's mainline June cuts will total roughly 78% of its original schedule, while United will cut 90% and American will cut the least, at 67%. Reductions at their regional affiliates are somewhat softer, totaling 67% for American and United and 75% for Delta.

Europe has seen some of the largest bailouts, but they were essentially focused on Air France-KLM, Lufthansa Group and parts of International Airlines Group. Lufthansa is emerging as a particularly contentious case, as it involves the government planning to take a 20% equity stake in the airline, raising concerns at the European Commission (EC) that the company's already dominant position in some markets will be further consolidated as other airlines fail to receive the same level of support.

The German government plans to inject €5.7 billion in the form of silent participation, provide €3 billion in loans and buy into the equity. Under certain conditions, the government stake could rise to 30% in the coming years, essentially giving it control of the airline. On the other hand, there are mechanisms in place for the repayment of the loan and the participation that foresee rising interest payments in outer years.

Lufthansa's board delayed a decision to approve the bailout based on concerns that potential slot remedies imposed on it by the EC were too onerous in the long term. But it conceded that there are no other viable options to retain solvency. The airline earlier had studied filing for the protective umbrella insolvency scheme but rejected it because it was seen as being too disruptive for passengers, investors and employees.

State Aid Distribution



Source: IATA

While all Southeast Asian flag carriers have been hit hard by the COVID-19 crisis, some are in a worse predicament than others. Thai Airways and Singapore Airlines (SIA) provide contrasting examples of how airlines' financial health before the pandemic has helped or hurt efforts to gain crucial funding support.

SIA fell to a rare quarterly loss due to the pandemic, although its strong balance sheet and significant state backing give it a brighter outlook than most of its peers. Thai Airways, in contrast, has been forced into bankruptcy court to restructure after its government could not justify pouring more money into a perennially underperforming company.

Thai declared on May 19 that it will proceed with its reorganization plan under the supervision of the Central Bankruptcy Court of Thailand. This move was decided by the Thai prime minister and his cabinet, as the government is the carrier's largest shareholder.

The government's plans for Thai Airways were in flux before the cabinet meeting. A 54 billion baht ($1.7 billion) bailout loan package had been considered as an alternative, but the government ultimately rejected that course and decided bankruptcy court was the preferred option.

The carrier has recorded substantial losses in all but three of the past 10 years, including a 12 billion baht loss in 2019. Thai has been working on a revised fleet and business strategy over the past several months, but its proposals have been rejected at least twice by the government.

Although the government shows no sign of completely divesting Thai Airways, it has reduced its majority stake. On May 25, the airline announced that Thailand's finance ministry had sold 3.17% of its shareholding to the Vayupak Fund. This is significant, as it drops the ministry's holding lower than 50%, which means the airline ceases to be classified as a state-owned enterprise.

Of course, Thai Airways is far from the only Southeast Asian flag carrier in a dire situation. Malaysia Airlines and Garuda Indonesia are other examples of airlines that were attempting financial turnarounds before COVID-19, and the pandemic now threatens to derail their efforts.

SIA entered the current crisis in a relatively strong financial condition. The carrier has for many years set the standard in this region for long-term profitability and sound management.

The airline did report a S$212 million ($150 million) loss for the fiscal year through March 31. This was primarily because it was forced to halt 96% of its operations in its fiscal fourth quarter, following a strong performance in the previous three quarters. The annual net loss was the first in the airline's history.

The carrier announced on March 26 that it would raise up to S$15 billion in equity through new share and bond issues. This move is supported by Temasek Holdings, the government-owned fund that is SIA's majority owner. Temasek committed to purchasing its own entitlement as well as any of the remainder that is unsold.

For the airline industry, a look at China is a look at what it hopes will be its own future in terms of traffic recovery and government support. Most of the sector is government-owned and not at risk of failing, as that would not be politically opportune.

With China being hit by the pandemic first, domestic capacity bottomed in the week beginning Feb.17 at 30% of the level of a year earlier, according to capacity data from OAG and CAPA – Centre for Aviation. Ordered back to work with the rest of the country, the airlines approximately doubled capacity in the following two weeks, but they could not sustain the rises: The trend flattened from early March to late April, when an upward trend in activity resumed.

Passenger load factors indicate that the airlines have been flying far more capacity than needed, presumably because the government wants this industry, like others, to appear normal. But the disparity has narrowed. China Southern Airlines and its affiliates, for example, filled 60% of domestic available seat kilometers (ASK) in March, improving to 65% in April, though still far short of the 83% of a year earlier. The figures for the groups centered on the other two big state carriers—Air China and China Eastern Airlines—were similar.

NAV CANADA

Tower controllers scanned the scene at Calgary International Airport.

ANSPs Ponder the Future After the Pandemic's End

> GLOBAL AIR TRAFFIC MOVEMENTS ARE DOWN 63%

> ANSPs ARE REELING FROM REDUCED REVENUES

Bill Carey Washington

Air navigation service providers expect a gradual, unsteady recovery from a coronavirus pandemic that has severely depressed air traffic and forced them to reassess their future workforces and facilities.

"It will not be a smooth recovery. It will be extremely volatile," said Kevin Shum, director general of the Civil Aviation Authority of Singapore (CAAS), when asked how air traffic control authorities will resume normal operations when the COVID-19 pandemic subsides.

"There will be periods of highs, and quite frankly, there will be periods when traffic drops again," he added. "In the short-to-medium term, it is extremely unlikely we will return to pre-COVID levels of traffic. It is fair to assume our base [workload] is going to be depressed for a considerable time."

Shum was one of four air navigation service provider (ANSP) chief executives who spoke May 20 during a Flight Safety Foundation webinar, along with Simon Hocquard, director general of the Civil Air Navigation Services Organization. They described financial, operational and training effects of the pandemic that reduced average global air traffic movements by 63% as of May 13 from January, according to Hocquard.

ANSPs in Europe and Canada that rely on airlines paying fees for air navigation services are reeling financially.

European ANSPs were managing 89% fewer flights than normal, "and this has added up to a €5 billion [$5.4 billion] hole in the air traffic finances in Europe," said Eurocontrol Director General Eamonn Brennan. "Our projections mean that we don't anticipate any significant resumption to growth until August. We believe we'll get back to 50% of our capacity in August."

With airline flight activity dramatically reduced, Eurocontrol's Central Route Charges Office is collecting less in route and terminal charges on behalf of its 41 member states, money that ANSPs use to finance air navigation facilities and services.

In early April, Eurocontrol member states agreed to help struggling airlines by deferring €1.3 billion in payments for air traffic services. In a second rescue package approved a week later, states authorized Eurocontrol to borrow up to €1.27 billion, which it will use to pay ANSPs 51% of their operating costs for four months. The Brussels-based agency will recover the money from the deferred payments and other later payments due to ANSPs.

"Eurocontrol and the states and ANSPs have basically deferred the collection of route charges for four months until next year, and this is saving airlines €1.3 billion," said Brennan. "In parallel to that, we're borrowing a similar amount to support ANSPs in Europe, because the reality is ANSPs will have no cash [from] basically March to the end of August, and this is going to result in significant economies."

Air traffic movements in Canada were down 75% in April compared to a year earlier. The drop-off has challenged Nav Canada, a privatized ANSP that recovers its costs from the service charges it levies on aircraft operators.

"We needed to mitigate very significant cash outflows, given the disappearance of our revenues," said Nav Canada President and CEO Neil Wilson. "Liquidity is absolutely the issue we face right now. Clearly, the challenge we face as we work together with our partners and with our customers is how are we going to collectively deal with the liquidity issue that we all face from the very significant downturn in passenger traffic and obviously the movement of aircraft as well."

On May 20, Nav Canada released a proposal for consultation to change its service charges as of Sept. 1. It calls for increased base-rate service charges averaging 29.5% and includes payment deferral mechanisms to ease the impact on airspace users, the ANSP said.

"What our business is going to look like in the next 5-10 years is very different from what it looks like now," Wilson advised. "We have very rigid institutional restrictions, we're people-intensive, we've got a lot of technology [and] sunk costs. It takes a long time to train [controllers]—we make a big investment in our people. All of those are things that we need to start changing."

The CAAS was experiencing an 85% decline in air traffic from prepandemic levels, and controllers were managing in a day the number of flights they previously handled in an hour, Shum said.

"It is extremely challenging and different for most of us, because the problem that we have had to deal with for the last few decades is constant, rising traffic. We're heading into an environment where we are limited in resources and the demand for our services is extremely volatile," Shum said.

OEMs Increase Efforts To Boost Confidence in Air Travel

> MANUFACTURERS STEP UP RESEARCH TO COMBAT TRAVEL FEARS

> ICAO AND GOVERNMENTS ATTEMPT TO ESTABLISH WORKABLE PROTOCOLS

Getting parked aircraft back in service will require instilling confidence in passengers and front-line workers.

MARTIN SYLVESTER/RITZAU SCANPIX/AFP/GETTY IMAGES

Sean Broderick Washington and **Jens Flottau** Frankfurt

Aircraft manufacturers are quick to note that nobody knows more about how their products work than they do, so their increasingly public involvement in helping guide industry through the novel coronavirus pandemic should come as no surprise.

Boeing has made the most visible move so far, standing up what the company says will be an industry-wide initiative. But others are working on both reassuring passengers and front-line workers as well as eyeing new products and protocols that could become part of a revised post-pandemic travel experience.

Boeing tapped longtime executive and former head of commercial engineering Mike Delaney to lead the Confident Travel Initiative, effective immediately. Delaney says the effort will take a strategic approach to developing new protocols and reaffirming current ones linked to keeping aircraft virus-free—part of a series of confidence-building initiatives seen as critical for the recovery of airline passenger demand.

Boeing will not make any major changes, such as rolling out new antimicrobial coatings, overnight. Certification ramifications alone make this improbable. But the company will eye such changes as part of future product development.

Delaney and his team will start by reaffirming practices such as what cleaners and materials are approved for different aircraft surfaces. They also will work with health experts to model various cabin scenarios to gain a deeper understanding of how viruses spread on an aircraft and what can be done to mitigate transmission risks.

The initial virus-transmission modeling uses a widebody cabin layout, Delaney says. Among the topics Boeing plans to explore: How does introducing variables, such as different airflow rates or multiple sick passengers, affect disease-transmission risk levels onboard, and what technology, such as UVC light sanitizing, might work to reduce risks.

"Air travel is coming back," says Delaney, a 31-year Boeing veteran who was vice president of engineering at Boeing Commercial Airplanes from 2010 to 2016 and most recently served as vice president of digital transformation. "As that happens, we want passengers and crews to board Boeing airplanes without hesitation," he says.

Boeing's work will focus primarily on its products but will have ramifications beyond its aircraft production line. Delaney envisions the manufacturers working together on low-hanging fruit such as not issuing conflicting guidance on once seemingly mundane issues as the types of cleaners they recommend.

The most critical factor when recommending cleaning products is ensuring cleaners do not damage materials or coatings found on aircraft. A close second factor is not having Boeing and Airbus differ on specific brands or versions of products that are basically identical. Recommending slightly different products without technical justification can drive up inventory costs for airlines and maintenance, repair and overhaul providers—something they try to avoid even when their balance sheets are strong.

Unlike Boeing, Airbus is not naming a senior executive to deal with the COVID-19 fallout full-time. But Jean-Brice Dumont, executive vice president of engineering, is leading an internal effort to look into cabin-health research and development projects that should be undertaken as a result of the pandemic. He is also behind an

Airbus effort to convey the message to the public that flying is still safe.

Airbus has begun to engage with authorities, airlines and airports to come up with a common risk analysis and define possible joint initiatives. Dumont says Airbus is concerned that measures will not be coordinated among different countries. It has not coordinated its response with Boeing or other OEMs, either.

The European airframer also is starting to look at what it calls the "cabin of tomorrow," which could include the greater use of self-sanitizing materials, Dumont says. Airbus CEO Guillaume Faury recently said that cabin health could become a significant area for future Airbus research investment.

Embraer provided some reassurance for passengers and cabin crew through a simple website article. The Brazilian OEM's commentary details how tests and simulations of cabin airflow during the development of its E-Jets helped determine the positioning of overhead passenger service unit (PSU) airflow valves, or gaspers.

"We found that the correct positioning of the PSU gaspers in relation to a person's head, and the resulting airflow, creates a kind of air curtain, or air barrier," Embraer says. "The cone-shaped flow pattern from the gasper disperses and then directs particles to air intake ports near the bins."

The air curtain formed by the gasper is why Embraer recommends that passengers turn the airflow on, "so that they always have a steady stream of air directed at their seat area."

The OEMs will collaborate at some level, likely through International Coordinating Council of Aerospace Industries Associations working groups. The council is part of a 25-member group working on an International Civil Aviation Organization (ICAO) initiative toward a comprehensive set of guidance for the entire air travel process.

ICAO is spearheading a Public Health Corridors concept, leading a task force that will attempt to develop a virtual travel bubble for flight and cabin crews and, eventually, for passengers. The task force's initial guidance, focusing on protecting cargo flight crews, was issued on May 11.

The ICAO work, in collaboration with both industry stakeholders and health experts, is emerging as the most logical global unification effort for regulators to lean on (*AW&ST* May 18-31, p. 25). The International Air Transport Association (IATA) is working on recommendations for airlines but is opposed to initiatives such as keeping middle seats empty and quarantining incoming passengers.

The OEMs are optimistic that their work can add factual context to the efforts of ICAO, IATA and others, providing a foundation for making decisions related to the aircraft-cabin and ground-services environments.

"We're working with all those organizations," Delaney says. "We believe that their ability to set a tone and standard is going to be critical for the global system to add capacity and productivity while allowing people to be safe."

TAD DENSON/AIRWND.COM

Manufacturers realize that a rebound in new-aircraft production is partially dependent on developing cabin health-related advances.

Boeing 777X Scrutiny Is Evidence of FAA Changes Post-MAX

- FAA IS REVIEWING 777X DESIGN AND OPERATIONS
- AGENCY PLANS FOR THE REVIEW TO BE A BRIDGE TO PERMANENT CERTIFICATION PROCESS CHANGES

Sean Broderick Washington

A group of internal FAA subject-matter experts is reviewing aspects of the Boeing 777X at the request of senior management—the latest sign that the 737 MAX saga is changing how the FAA does business.

The Technical Advisory Board (TAB) is examining several broad areas—including human factors, airworthiness, operations, maintenance and system safety assessments (SSA)—a senior government official familiar with the project says. The tasks align with issues highlighted in a U.S. Transportation Department special committee report released in January, which made recommendations on how the agency can improve certification.

Several of them, notably increased involvement by human factors experts and more thorough scrutiny of SSAs, have been cited in other reports that, like the Transportation Department review, were prompted by two fatal 737 MAX accidents in five months. The accidents killed 346 people and led regulators to ground the fleet and review the model's certification.

The FAA often uses TABs composed of agency experts not involved in the day-to-day project they are examining to look at specific certification or airworthiness issues and provide recommendations to agency staff. The FAA has a TAB reviewing some of Boeing's proposed changes to the MAX, which remains grounded while Boeing modifies its flight control software and pilot training. Non-FAA experts are among those on the MAX TAB, which is reviewing the agency's conclusions, in-

cluding findings of compliance, related to Boeing's proposed changes.

The 777X review team is acting more like a traditional TAB, providing advice to the FAA's 777X certification team, and its review extends beyond design and into the operational environment. For example, the team's review of the newest 777's highly scrutinized folding wingtips will focus as much on human factors and operational issues such as flight deck interfaces and deicing as it does on the system's design.

Boeing is working with the TAB, the official says, providing technical documentation and other support to members. The TAB has about 16 members and taps deeper FAA expertise on an as-needed basis.

The TAB is not on a specific schedule, and its work is not expected to affect the certification timeline of the 777-9, the first model in the new family. Two 777-9s are in flight testing, and two more are expected to join them. First deliveries are planned for next year.

In the longer term, the FAA sees the 777X TAB as a bridge to a permanent shift the agency is planning for its certification process, the official says. The change is part of the FAA's response to the MAX reports and to a few outstanding recommendations from previous certification reviews.

The FAA's recently released response to the Transportation Department committee report highlights several focus areas. Among them is to "approach certification holistically by treating the aircraft as complex systems, with full consideration of how all the elements in the operating system interact," the agency wrote.

The FAA also plans to "prioritize" a long-stalled revamp of SSA rules and guidance. Launched in 2011 with the intent of adopting recommendations made by a rulemaking advisory committee and standardizing with the European Union Aviation Safety Agency, progress quickly slowed. The FAA now plans to publish a draft rule by November.

"The planned new and/or updated guidance and standards will address issues such as validating assumptions made in the system safety assessments concerning trained flight crew recognition of single and multiple failures, tracking and validating changes to key safety-related assumptions, and coordinating the manufacturer's [safety management systems, or SMS] program with an operator's SMS program," the agency says.

The FAA plans to launch a policy review team in the coming weeks linked to the SSA process improvements. One of its prime areas of focus will be integrating more human factors expertise into not just SSA evaluation but into the entire certification process. The agency is recruiting at least eight human factors specialists who will be assigned to its Aircraft Evaluation Group (AEG). The AEG is the primary link between the FAA's Aircraft Certification and Flight Standards units. A need for better coordination between the two organizations was among the issues highlighted in reviews of the MAX certification process.

In both MAX accidents, Lion Air Flight 610 in October 2018 and Ethiopian Airlines Flight 302 in March 2019, software added to the MAX that can automatically move the stabilizer in certain flight profiles activated when it was not needed. Neither crew reacted to the resulting aircraft nose-down commands as Boeing had believed they would, and both accident sequences ended in fatal dives.

Reviews of the MAX certification found that not only were Boeing's pilot-reaction assumptions wrong, the stabilizer SSA had not been not updated after changes to the software—the Maneuvering Characteristics Augmentation System flight control law—were made late in the aircraft's development. Some FAA experts knew about the changes, but because they were not documented in an updated SSA, key FAA engineers were left out of the loop.

Better communication might have led the FAA to order design changes that would have improved the MAX's safety, a team of 10 regulators probing the issue concluded last October. The agency believes that more proactive involvement during certification by a broader range of experts, notably human factors specialists, will reduce the risk of similar mistakes.

One SSA-related area on which FAA pushed back is the committee's call to remove exclusions for skill-related errors associated with manual control of the aircraft. In theory, this would force manufacturers to ensure their designs compensate for mistakes during not only complex hand-flying tasks but also routine ones such as errors on crosswind landings.

Such an approach "might be viewed as driving manufacturers toward a single solution—a fully autonomous aircraft," the FAA says. "The FAA seeks to avoid unnecessarily limiting the range of potential solutions."

The agency also has tasked an advisory committee to examine how certification can reasonably consider an aircraft's global operating environment when developing operational requirements. The FAA and other regulators that certify aircraft are facing calls to develop broader training and maintenance requirements that take into account different regulatory standards, such as pilot qualification minimums, around the world, as opposed to the framework that they have established for their airlines.

The FAA says it will assign a "senior manager" to help keep the tasks outlined in its response on track and "oversee the implementation of all activities."

A special panel of internal FAA experts is reviewing the 777X design.

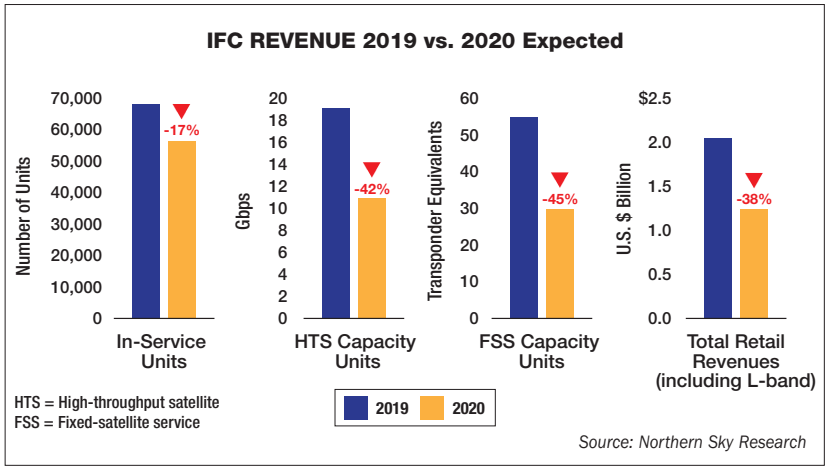
BOEING

Coronavirus Is a Crucible for IFC/IFE Businesses

- BIG DROPS REPORTED IN IFC/IFE REVENUE
- INSIDERS AND ANALYSTS HAVE SUNNY VIEW BUT ACKNOWLEDGE DARK CLOUDS

Michael Bruno Washington

The inflight connectivity and entertainment (IFC/IFE) sector could take years to return to pre-COVID-19 business levels, according to a new analysis. But while the sector has followed commercial and business aviation into a deep rut, analysts and executives say they can see sunnier days ahead.



A new report from Northern Sky Research sees almost $37 billion in cumulative IFC revenue through 2029, despite a near-term plunge due to the novel coronavirus. Overall, the sector should see a compound annual growth rate of 9.8% in the period.

Still, business probably will get worse before it gets better. "Market difficulties are likely to remain for an extended period" and not abate before 2022, Northern Sky acknowledges. "This is likely to occur as pandemic progression results in continued grounded aircraft and financial pressures on airlines, OEMs ramping down aircraft production rates, economic slowdown scenarios, and possible flying hassles and psychological resistance deterring travelers."

IFC and IFE providers echoed as much in recent quarterly teleconferences. "It's an airline-related business," says Thales Chairman and CEO Patrice Caine, and "will be affected as well by this aeronautical crisis."

Thales is a multi-industrial provider, so it is better suited to weather the downturn. IFE was an €800 million ($878 million) business in 2019, 11% of their sales. But in the first quarter of 2020, the Thales aerospace segment that houses IFE was the hardest hit of the French company's divisions, due to the drop in both airline activity and production cuts by aircraft OEMs.

"The impact will be very significant, for sure, in the short run," Caine told investors and analysts April 28.

Competitors are having a more difficult time. Gogo reported a net loss of $84.8 million for the first quarter ended March 31, which includes charges of $46.4 million related to the impairment of certain long-lived assets and $6.8 million in additional credit loss reserves taken during the quarter. The quarterly loss was fourfold compared with a year before.

Tragically, the embattled company—which in recent years considered looking for a buyer—was expecting a bright year at the start of the last quarter. "I am going to steal a little Charles Dickens to put the quarter in perspective, and that is that the first quarter was definitely a tale of two quarters," Gogo CEO and President Oakleigh Thorne said at the start of his quarterly report. "It was the best of times in January and February and close to the worst of times in March."

Unfortunately, April business results were even worse than in March, he continued. That was when commercial air traffic dropped 95% from a year before, and 105 of 193 airlines globally were not flying at all. Business aviation also was down 80%. Roughly 30% of Gogo's 5,700 business jet air-to-ground customer accounts cut their spending with the IFC provider, including 940 account suspensions and more than 750 service plan downgrades.

The company—which a year ago concluded a major restructuring—is undertaking another round of dramatic changes to bolster its finances. Gogo furloughed 54% of its workforce effective May 4, affecting around 600 employees across all three of Gogo's business segments, as well as at its headquarters.

The company applied for an $81 million grant and a $150 million loan under the recently enacted U.S. Coronavirus Aid, Relief, and Economic Security (CARES) Act. If it receives funding, "it will modify the announced personnel actions to comply with the terms of that assistance." Compensation was cut for everyone else, including 30% for the CEO and directors on the board and 20% for the rest of executive leadership.

On May 11, executives outlined ongoing negotiations with satellite suppliers and customers to redo contract terms. They also are delaying aircraft equipment installations at airlines, especially those tied to older deals where Gogo "heavily" subsidized equipment under a previous business model. To play it safe, executives now are planning on practically no more installations the rest of this year. Other cutbacks include deferring capital equipment purchases and reducing spending on marketing, travel and nonessentials.

Thorne said the cost savings could save Gogo up to $170 million in cash through the end of 2021. But S&P Global Ratings on May 12 reaffirmed its negative credit watch on Gogo, as its liquidity will remain under pressure. The credit rating agency said by the end of next year Gogo will have burned $100 million of what was a $211 million cash pile at the start of April.

"We believe the company could continue to withstand a near-full, global, commercial ground-stop for a few months, but the long-term viability of the business depends on the duration passenger volumes will be near zero and the length and pace of the recovery—which is highly uncertain at this point," S&P credit analysts say.

COVID-19 Infects Defense Industry With F-35 Production Slowdown

> LOCKHEED MARTIN EXPECTS 117-124 F-35 DELIVERIES IN 2020

> SECOND-HALF RAMP-UP STILL POSSIBLE

Steve Trimble Washington

This was supposed to be a relatively easy year for Lockheed Martin's F-35 production. As 2020 began, the stealth fighter program's three-year growth spurt had subsided after annual deliveries more than doubled between 2017 and 2019. Lockheed planned to deliver 141 F-35s in 2020, only seven more than in 2019.

But the F-35 supply chain is not immune from the global disruption caused by the COVID-19 pandemic. After signaling during a first quarter earnings call in April that a production slowdown was likely, Lockheed confirmed the impact on May 19. The company issued a new forecast of 117-124 F-35 deliveries this year. If Lockheed is unable to recover in the second half, the slowdown would mark the first year-over-year decrease in F-35 deliveries since the program began.

"However, we will accelerate production when we return to pre-COVID-19 conditions and could see this number decrease," the company says.

The company's new financial guidance reflects the lower F-35 delivery total, with net sales for the year falling to a range of $62.25-64 billion from $62.75-64.25 billion. Other large F-35 suppliers include Northrop Grumman (center fuselage, radar), Raytheon Technologies (engine, distributed aperture system) and BAE Systems (aft fuselage, electronic warfare suite).

It was not immediately clear which customers and variants would be affected by the potential shortfall of 18-24 F-35 deliveries in 2020.

The Defense Department is closely watching the F-35, its single-largest production system. So far, senior acquisition officials expect the overall impact of the novel coronavirus on weapon system production to be manageable. But the Pentagon leadership considers the military aircraft industry an exception. Although demand and domestic U.S. military spending remain intact, the military aviation supply chain's links to the collapsing commercial aircraft market is causing delays.

"I think [military] aviation has had a more acute sensitivity to supplier disruptions, largely driven by the massive upheaval in the commercial aviation market," said James Geurts, assistant secretary of the Navy for research, development and acquisition. "Many of the aerospace companies were blended between military and commercial, and with commercial just falling through the floor, their abilities to stay open and keep their workforce has been a little bit more challenged."

Another sector Geurts is watching is the market for command, control, communications and computers and intelligence (C4I). "We're trying to track all of it," he says. "But the most immediate impact we've seen has been on aviation."

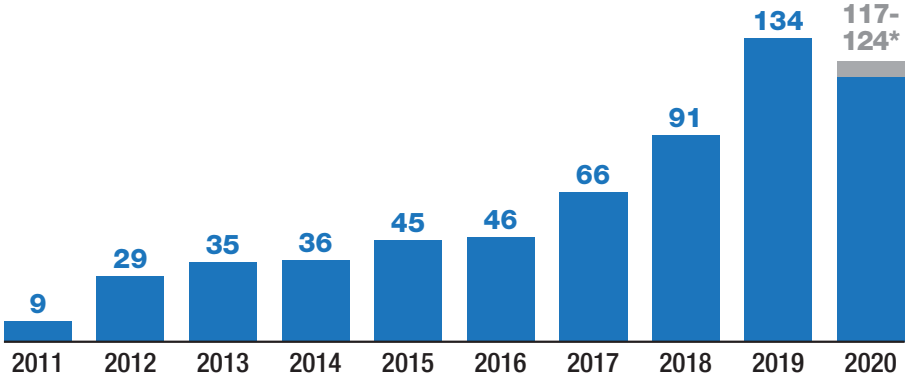
Lockheed's F-35 assembly line in Fort Worth was hit hard by the COVID outbreak in mid-April. One employee, Claude Daniels, died after reporting COVID-19-related symptoms to a supervisor. Another F-35 employee, who survived, broadcast a Facebook Live video from his hospital bed, pleading with his unionized co-workers to sanitize their workspaces even if it is not in their job description.

The company's management has said that the F-35 assembly line adopted new protocols in response to the COVID-19 pandemic, which included regularly sanitizing equipment and quarantining employees exposed by co-workers or others to the virus.

The COVID-19 response is not the only pressure on the F-35's production system. Lockheed exceeded the overall delivery target by three aircraft in 2019, but slower production of the less mature F-35C airframe nearly caused the company to miss the annual goal. To compensate, Lockheed moved up deliveries of four F-35As originally scheduled for 2020 to the end of 2019, allowing the company to beat the delivery target by three aircraft instead of missing it by one.

Before the impact of the virus, the F-35's global supply chain was already strained by the three-year production ramp-up from 2017 to 2019. Late part deliveries jumped to 10,000 in 2019 from 2,000 in 2017, according to a May report by the Government Accountability Office (GAO). Monthly parts shortages, meanwhile, leaped to 8,000 in July 2019 from 875 a year before, the GAO says. The shortages represent a fraction of the 300,000 parts in each F-35, but the trend offered a glimpse of the pressure on the supply chain to meet demand during the ramp-up.

F-35 Deliveries



*Estimated

Source: Lockheed Martin

SOAR Points

> ELITE AVIATION UNIT FLEET STRATEGY DEPENDS ON U.S. ARMY DECISIONS

> THE FIRST A/MH-6M BLOCK 3 IS IN ADVANCED TESTING

Steve Trimble Washington

Having been founded two years after the 1979 introduction of the Sikorsky UH-60A Black Hawk, the U.S. Army's elite 160th Special Operations Aviation Regiment (SOAR) came into existence with a fleet management problem.

The Army's premier aviation unit operates a fleet of helicopters, including 66 Boeing MH-47G Chinooks, 42 Boeing MH-60M Little Birds and 72 MH-60L/M Black Hawks, that are essentially hand-me-downs. To tailor each helicopter type to the regiment's unique operating style—characterized by long-range, high-speed, nap-of-the-earth flight mostly at night—the Special Operations Command (SOCOM) has paid dearly over the last 40 years to support extensive postproduction modifications, along with regular upgrades that remain in progress.

"As everyone knows, the changes you make to an [aircraft] design postproduction are the most expensive changes you're going to make," says James Smith, the acquisition executive for SOCOM.

As the Army moves forward with two new high-speed-rotorcraft acquisition programs, its most elite aviators see a once-in-a-generation opportunity to break that hand-me-down cycle. Instead of receiving aircraft that must be extensively modified after rolling off assembly lines, SOCOM acquisition officials are seeking to build the regiment's unique design needs into the aircraft from the beginning.

"So now we can make the design changes during the design phase," Smith said, speaking on a teleconference call with journalists during the command's virtual Special Operations Forces Industry Conference on May 12.

U.S. AIR FORCE

The Army's special operators prefer a new assault aircraft that carries troops internally, but only one of the Army's selections for the Future Attack Reconnaissance Aircraft competition comes with a cabin.

The 160th Regiment has already identified the Army's Future Attack Reconnaissance Aircraft (FARA) as the likely replacement for the Little Birds and the Future Long-Range Assault Aircraft (FLRAA) as the obvious successor to the Black Hawk. The Chinook is expected to keep flying "indefinitely," but FARA and the FLRAA could replace nearly two-thirds of the 160th's fleet over the next 20-30 years.

Except it may not work out that way. Early design and acquisition strategy choices by the conventional Army has left the special operations branch uncertain that FARA will address the 160th's requirements and that the FLRAA will arrive on time. Moreover, the Army's decision to defer orders for the CH-47F Block 2 adds to SOCOM's concerns. The 160th is now the only customer over the next five years for the Block 2 upgrades required for the Chinook, which may not represent enough business to sustain the industrial base around the program.

The ambiguity of the 160th's fleet-replacement plans is not likely to be resolved for at least several years, so in the meantime SOCOM is continuing to fund significant upgrade programs for the each of the existing helicopter types.

On March 26, the Army selected the Bell 360 Invictus and the Sikorsky Raider X to enter a three-year competition, which includes a flight demonstration of prototypes, for the FARA contract. The Army's goal is to select an aircraft capable of at least 180 kt. to replace the armed scout role performed by the now-retired Bell OH-58D Kiowa Warrior. But the winning FARA design also will be a candidate for the challenging task of replacing the 160th's fleet of A/MH-6Ms.

Featuring a compact, 27.4-ft. rotor diameter, the Little Bird is tasked to perform a variety of roles including close air support in tight urban spaces and infiltrating teams of four special operators carried on external planks. The latter feature offers a powerful visual image of soldiers riding into battle on the outside of an assault helicopter but is actually something SOCOM was forced to accept due to the limitations of an existing aircraft design.

For the A/MH-6M replacement, SOCOM has specified a requirement for an aircraft that can carry four to six troops internally, says Geoffrey Downer, SOCOM's program executive officer for rotary-wing aviation. That requirement creates a potential problem for SOCOM in the FARA competition as it is now defined.

"The Sikorsky [FARA] configuration is configured currently to carry troops, but the Bell configuration is

U.S. ARMY

A sticking point for an MH-60M (foreground) replacement is a design that comes with a refueling probe, and Special Operations Command needs foreign orders to help keep the MH-47G Block 2 line sustainable.

not," Downer said during a teleconference with reporters. "That provides an interesting problem for us in the future, where if the Army selects one of those solutions [and it is] not able to carry troops, then we might end up with a mixed fleet going forward."

Sikorsky designed the compound-coaxial Raider X with an internal cabin, which potentially meets the SOCOM requirement to carry up to six troops internally. Bell's configuration for the 360 Invictus, which includes a main rotor augmented by a supplementary power unit, offers no space to carry troops internally. It is possible Bell could redesign the 360 Invictus after the prototyping phase or—reprising the AH/UH-1 split—offer two airframes that share a common rotor system. But either option could require an additional investment by the Army or SOCOM at a time when defense budgets are expected to flatten or decline.

Downer also offers a third option. Rather than accepting the Army's selected FARA after 2024, SOCOM could acquire a different aircraft to replace the A/MH-6M fleet.

"If we require greater lift capability than that [FARA] aircraft can support, going forward, we could look at another commercial variant of an aircraft that's a little bit larger-class aircraft to do that mission," Downer says.

The 160th faces no immediate replacement decisions for the A/MH-6M. A five-year-old upgrade program to the Block 3 standard is set to deliver the first aircraft by September, Downer says. As the fleet transitions to the Block 3 version, the Army plans to continue operating the Little Bird for 10-15 more years, he adds.

The 160th's only single-engine helicopter has evolved significantly over nearly 40 years. The unit inherited an aircraft with a two-blade rotor and a 2,500-lb. maximum takeoff weight (MTOW). The Block 2 version of the A/MH-6M delivered after 2004 features a six-blade rotor and a 4,700 lb. MTOW.

The Block 3 adds performance and cockpit upgrades, along with newly machined airframes. The main rotor's six blades are replaced with longer, asymmetrical and composite airfoils for increased lift. The tail rotor and tail rotor gearbox were moved to increase control authority, and a trim button was added to the collective to reduce pilot workload. The new version of the A/MH-6M also features a new cockpit architecture called the Aviation Management Systems (AMS), Downer says. The AMS adds new displays that can show moving maps, videos and high-resolution sensor imagery.

The Army's dueling options for the high-speed FLRAA requirement—Bell's V-280 Valor or the Sikorsky-Boeing SB-1 Defiant—offers the natural replacement for the Black Hawk fleet, but SOCOM is hedging its bets with a long-term upgrade road map for the fleet that performs the Direct Action Penetrator mission.

The Block 1 version of the MH-60M, which is set to arrive in 2025, introduces the 3,000-shp GE Aviation T901 engine, the K_u-band Silent Knight terrain-following/terrain-avoidance radar and a newly developed Sierra Nevada Corp. Degraded Visual Environment system, Downer says. Follow-on Block 2 and 3 requirements also have been drafted for the fleet to offset the impact of any delays in the FLRAA program.

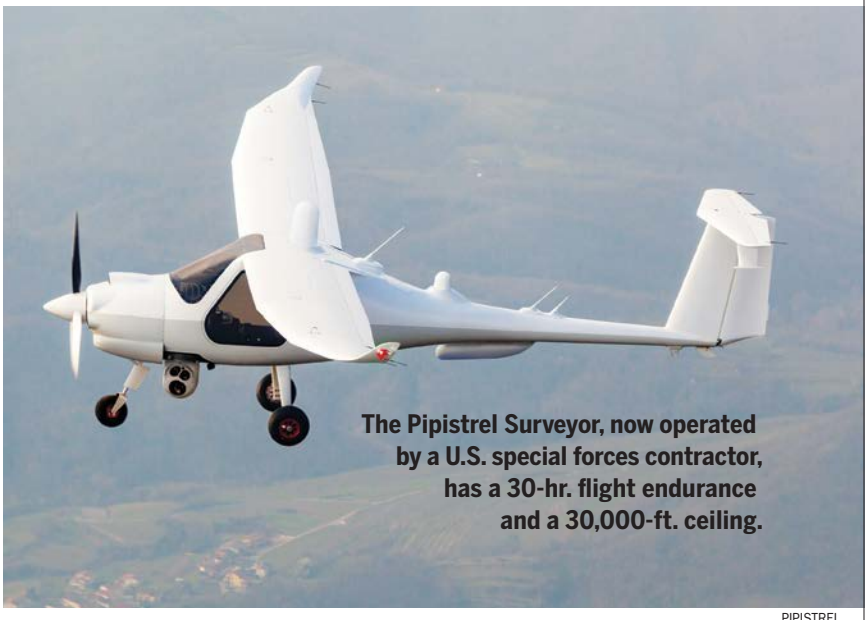
"Our plan is really dependent on what the Army is doing with the Future Vertical Lift program and how it stays on schedule," Downer says. "If it turns out that everything falls in line with the [FLRAA], then we will transition seamlessly into that [program]. If there is an issue with the Army's program, we will continue to march on with future Block 2 and Block 3 modifications for the MH-60 fleet."

Seeking to avoid one of the most extensive postproduction upgrades for the MH-60M, SOCOM successfully lobbied the Army to include an air-refueling requirement in the baseline design for the FLRAA, Downer says. However, the Army is not paying to certify the air-refueling capability, so that funding would come out of SOCOM's acquisition budget. SOCOM expects to receive the first prototype of a special operations version of the FLRAA aircraft in 2026 or 2027 to perform a user evaluation, which will inform decisions on any additional modifications, he says.

SOCOM Reveals Deployment of Slovenian-Made UAS

> AFRL CONVERTED PIPISTREL SINUS TO UAS

> U-28 CREWS WILL TRANSITION TO ARMED OVERWATCH



The Pipistrel Surveyor, now operated by a U.S. special forces contractor, has a 30-hr. flight endurance and a 30,000-ft. ceiling.

PIPISTREL

Steve Trimble Washington

A new class of low-cost, long-endurance unmanned aerial systems (UAS), including a newly confirmed Slovenian-made aircraft, have entered U.S. Special Operations Command's (SOCOM) fleet plans, even as budget concerns arise that complicate a proposal to use the new Armed Overwatch platform to replace the manned Pilatus U-28 fleet over the next 8-10 years.

SOCOM reveals to Aviation Week that the Pipistrel Surveyor, an unmanned military version of the company's Sinus light sport aircraft, has been deployed as part of a proof-of-concept experiment. The Air Force Research Laboratory (AFRL) converted the Pipistrel aircraft for SOCOM, installing sensors to collect full-motion video and signals intelligence, SOCOM says.

The deployment of the contractor-operated Surveyor could be followed by other long-endurance UAS types as SOCOM looks for low-cost options to supplement special forces' fleets of General Atomics Aeronautical Systems MQ-1C and MQ-9 aircraft.

SOCOM "plans to continue working with the services and industry partners to identify low-cost, high-endurance airborne intelligence, surveillance and reconnaissance solutions," a spokesman said in a statement.

Pipistrel, which now lists the U.S. and Chinese air forces as customers on its website, confirms that "many governments, ministries and nongovernmental agencies" have deployed the aircraft for surveillance missions. But the company says it cannot comment on the details of the SOCOM operation.

A SOCOM acquisition official hinted at the Pipistrel deployment in a public presentation on May 13 as part of the virtual Special Operations Forces Industry Conference. Col. Melissa Johnson, the program executive officer for fixed-wing aircraft acquisition, showed a picture of the Pipistrel aircraft on a presentation slide adjacent to the MQ-1 and MQ-9, but she did not identify the aircraft or describe what role it has in the SOCOM fleet.

Johnson told the audience of industry attendees, however, that SOCOM is seeking new low-cost alternatives to the MQ-1 and MQ-9 for long-endurance surveillance missions.

"I'm really looking for industry to come tell me what type of lower costs [can be achieved], not just from a production standpoint but, again, overall sustainability," Johnson said. "You can have a lower cost, but it's got to be survivable and reliable in any environment we intend to work in. We'd be very interested to see what the industry has out there. I think this is a new growth area for us."

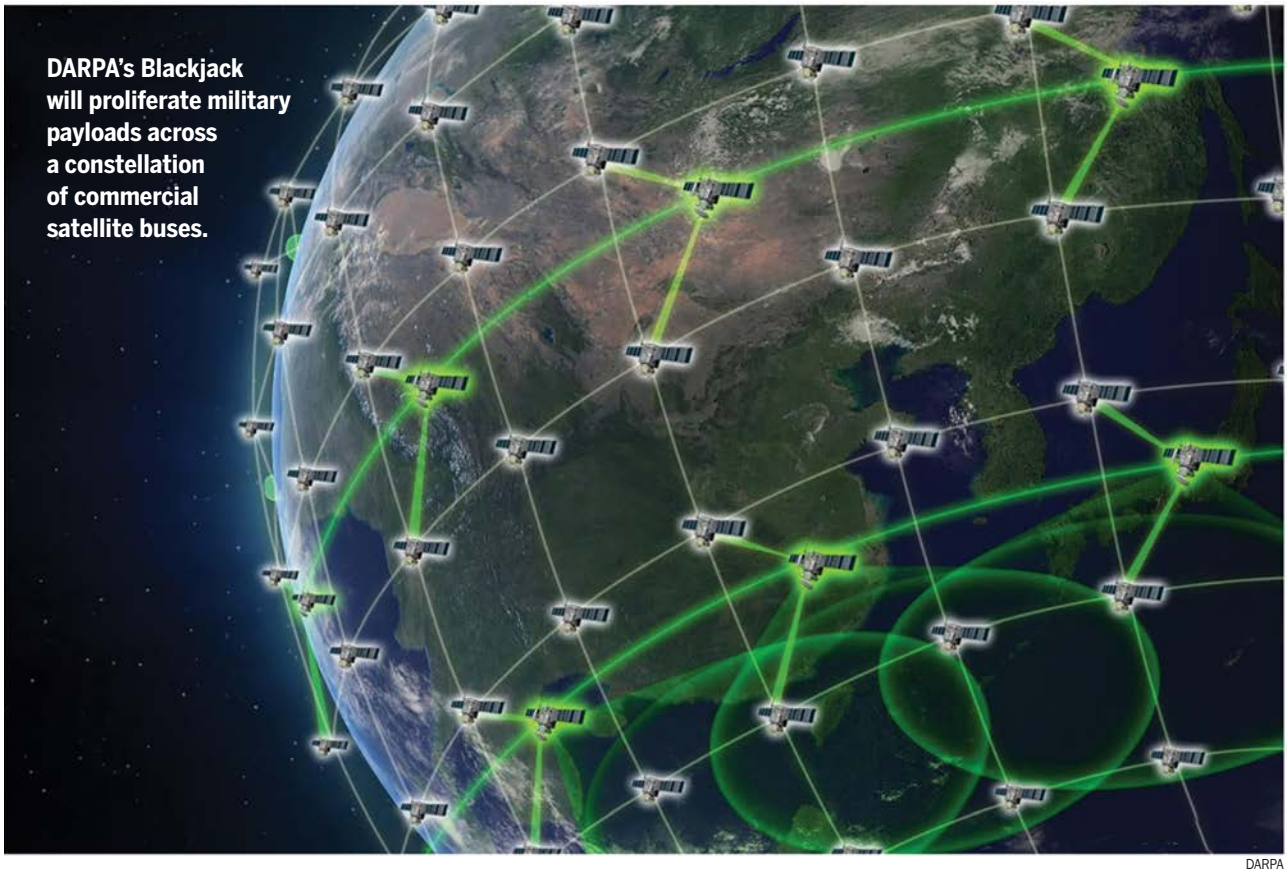
"The MQ-9 and MQ-1 are still workhorses," she added. "But I think some complements and supplements, depending on the [geographic] area that the users are in, might need some additional capabilities."

SOCOM is expanding its UAS portfolio at the same time that it is overhauling its fleet of manned, light aircraft for intelligence, surveillance and reconnaissance (ISR) missions. Since 2006, Air Force Special Operations Command (AFSOC) has operated a small fleet of about 25 U-28s, a military ISR variant of the single-engine Pilatus PC-12.

It is not clear how the U-28s would operate alongside the planned fleet of Armed Overwatch aircraft, which SOCOM plans to introduce into service as early as next year. The U-28's official retirement date still is not set, but Johnson confirms to Aviation Week that U-28 pilots and maintenance crews will transition to the Armed Overwatch fleet as it arrives and continuing through 2027.

That transition plan should ease the pressure on AFSOC to rapidly recruit and train a new cadre for the Armed Overwatch mission, but it also confirms details about the requirement for the new fleet. Unlike Air Combat Command's desire for a light attack platform with fighter-like agility, AFSOC prefers an aircraft that can observe targets and deploy weapons in level flight.

SOCOM's acquisition strategy sets a blistering pace for the Armed Overwatch source selection process, but Jim Smith, the command's acquisition executive, acknowledges that politics might interfere. The Armed Overwatch program is officially designated as a "new start" in the fiscal 2021 budget now under review by Congress. If lawmakers are unable to pass a defense appropriations bill on time, a planned flight demonstration in November and contract award by next April could be delayed up to a year, Smith says.



DARPA's Blackjack will proliferate military payloads across a constellation of commercial satellite buses.

DARPA

Autonomy in Orbit

> SUPERCOMPUTER CHIPS AND LASER INTERSATELLITE LINKS ARE KEY

> AUTONOMOUS CONSTELLATION DEMONSTRATION TO BEGIN IN 2022

Graham Warwick Washington

DARPA plans to launch a series of risk-reduction satellites this year in an effort to ensure the success of its Blackjack program to tap into the commercial space market and demonstrate that low-Earth-orbit (LEO) constellations can perform military missions as effectively as geosynchronous satellites.

The small satellites will test in orbit the supercomputer processors, optical intersatellite links, onboard artificial intelligence (AI), data fusion and software-defined radios that will enable autonomous LEO constellations to provide resilient and persistent overhead coverage direct to forces in combat.

"In Phase 1, we intentionally went backward to how you might do a normal contract approach. We didn't work with a big prime. We worked with individual providers who have these commoditized commercial buses," says Paul "Rusty" Thomas, DARPA program manager.

"We figured out what size, weight and power will be available on those buses for high military-utility payloads across different types of missions, whether it's OPIR [overhead persistent infrared], RF [radio-frequency] geolocation, tactical communications or PNT [position, navigation and timing]," he says.

The goal of Blackjack is to leverage commercial technologies to enable a military constellation of LEO satellites, connected by a high-speed mesh network, to be constructed and replenished using relatively low-cost nodes—less than $2 million per payload and under $6 million per launch.

Phase 1 identified areas of technical risk in the commercial off-the-shelf (COTS) approach. "You can put a lot of processing power in space, but a lot of the COTS approaches are going to have vulnerabilities in low Earth orbit through radiation," Thomas says.

The first of the risk-reduction launches, Mandrake 1, is a cubesat that will carry supercomputer processors. "We are putting some of our supercomputer, AI-enabled chips into play to show that you can have tens of teraflops of processing capability on orbit," he says.

"It's hard to say I'm going to develop an algorithm that uses this huge processing power and put it in orbit because there aren't too many chips that work great in orbit, especially at the cost point we need for proliferated LEO, where we have a lot of low-cost payloads," Thomas says.

While Mandrake 1 is intended to show these chips will work in orbit, Mandrake 2 will test the optical intersatellite links (OSIL) that will enable the Blackjack satellites to form a mesh network in orbit.

"If you want to get broadband connectivity between spacecraft and not have to worry about spectrum allocation with RF links, then lasers and putting fiber optics into space without the fiber is a good way to do it, but there aren't low-cost, very reliable optical intersatellite links available now," he says.

To be conducted in conjunction with the U.S. Space Development Agency, Mandrake 2 will demonstrate the OSILs. "So now you have the su-

percomputers in space, and you have the ability to provide a mesh network with laser communications between the nodes," says Thomas.

The third risk-reduction mission, Wildcard, will fly an advanced software-defined radio that can provide tactical information direct to users on the ground, in the air or on ships, "in seconds to minutes," he says, via a wide range of existing and planned data links.

A fourth Phase 1 mission, Loft Orbital, will demonstrate data fusion on orbit. "We want to put these brains in space and start to put together the data fusion to bring in the inputs from the sensor layers, [and] maybe tip and cue from other systems that are not in LEO," Thomas says.

Loft Orbital will demo the ability to host third-party algorithms, also called massless payloads, that can aggregate huge amounts of data from other satellites and produce a "coherent, limited amount of tactically relevant information that we can then send directly to the warfighter," he says.

Planned for ride-sharing launches this year and early in 2021, the Phase 1 risk-reduction missions will "give us confidence in Phase 2, as we select payloads for the demo, that we have a good chance of putting them into a constellation of 10-20 satellites that we can run and not have to worry about an individual failure of a chip or an OSIL that stops us having a successful constellation-level demo," says Thomas.

DARPA's goal is to fly the risk-reduction missions well before assembly, integration and test of the demo spacecraft begins, "so if we do have a problem, we can resolve it on the ground before we build the first two spacecraft of the Blackjack constellation," he says.

For the demo, DARPA is evaluating commercial LEO satellite buses from Airbus, Blue Canyon Technologies and Telesat, all of which are through their preliminary design reviews (PDR). Final selection of the buses will happen this year.

The Pit Boss autonomous mission management system that will fly on every Blackjack satellite has also completed its PDR at SEAKR Engineering. The constellation-level on-orbit autonomy enabled by Pit Boss will allow a large number of satellites to be managed by only a few people on the ground. "Somewhere around two people to watch a constellation is what our goal is day-to-day," Thomas says.

"We are not going to require the ground to talk to the space layer to do the mission. The satellite operations center could be under cyber or kinetic attack. You don't want any single point of failure on the ground or in space that could take out your proliferated approach," he says.

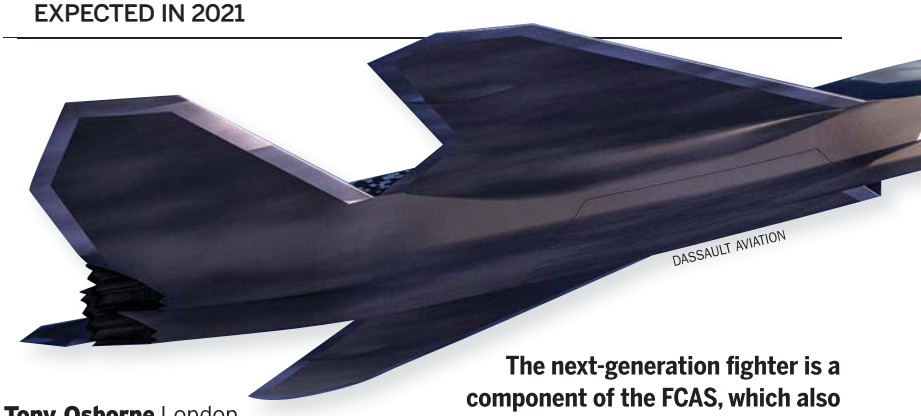
"That teraflop Pit Boss brain will be on every node, and they will be able to operate autonomously with or without human intervention as they do the sensing and data fusion," Thomas says. "With the type of formation we are looking at, with highly inclined orbits, we can provide constant custody of the ground with a small staff for day-to-day operations and only contingency staff to handle anomalies. The hard part is showing we can build a constellation-level autonomy layer that operates without minute-to-minute support from the ground."

Several sensor payloads are under consideration for the Blackjack demo: OPIR from Raytheon Technologies; RF from Northrop Grumman, Trident Systems and Systems & Technology Research; PNT from Northrop; OSIL from SA Photonics; and electro-optical/infrared from L3Harris Technologies. Small business Augustus Aerospace is working

Autonomous Technology Prompts Ethical Calling for German FCAS

> INDEPENDENT PANEL LOOKS TO KEEP FCAS WITHIN LEGAL GUIDELINES

> DECISION ON COMBINATION OF FIGHTER AND REMOTE CARRIERS EXPECTED IN 2021



The next-generation fighter is a component of the FCAS, which also includes unmanned systems, legacy fighters and the combat cloud.

Tony Osborne London

With the European Future Combat Air System likely to feature high levels of autonomy and artificial intelligence, Germany wants to ensure those technologies are used responsibly and ethically.

German popular opinion has long been wary of the use of military force—understandable given the country's wartime past.

Recent political debates, one on the arming of unmanned air vehicles and another on the country's continuing role in nuclear deterrence, appear to reinforce this.

But the Future Combat Air System (FCAS), which Germany is developing jointly with France and Spain, calls for the creation of an advanced combat aircraft and the use of unmanned remote carriers and advanced weapons. These will all be linked together in an airborne network—a combat cloud—while artificial intelligence (AI) will analyze target and mission data to support the decisions taken by the human pilot, whose task will ultimately more likely be that of a mission commander.

But the inclusion of such technology is prompting questions about the level of human influence in the system and concerns that it could lead to a flying killing robot.

on a payload for the U.S. Army Space and Missile Defense Command.

"We had to put on contract quite a few payloads, almost double-digit, to look at all those various types of missions and how they would work with the buses," Thomas says. Lockheed Martin, selected as the satellite integrator for Blackjack, is working to define the interfaces between these payloads and the buses by the end of Phase 1.

"We are looking at options to put two or three payload types on a given bus . . . and use different types of buses for the same payload. We are working with Lockheed to put together a technology they call Slot Machine to show us how the same payload can work on different buses," he says.

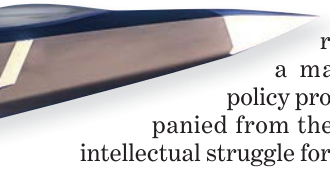
"Blackjack takes those commoditized buses and removes any equipment that talks with the commercial user," Thomas says. "If we can take that element out, with small changes to the production line, we have 50 kg [110 lb.] or more of mass we can use for a military-dedicated payload."

DARPA wants to minimize the changes so it can realize the cost benefit of using buses that are in mass production. Lockheed will set up an integration facility in Sunnyvale, California, where it will receive buses without the commercial user elements and use the open space to install the Pit Boss, payload and OSIL "and show how they can do that in a fast cycle time and get it to the launch site quickly," he says.

Commissioning of the first two demonstration satellites is planned by the end of 2021. The remainder of the constellation is to be launched beginning around mid-2022, and the demonstration will be completed in 2023. The number of satellites—between 10 and 20—and their payloads have yet to be decided.

Thomas says the on-orbit autonomy and networking technologies demonstrated by Blackjack are planned to transition to a program called Casino (for Commercially Augmented Space Inter-Networked Operations) that has been started by the U.S. Space Force with the Air Force Research Laboratory.

Now, in an unusual step, Airbus and the Bonn, Germany-based Fraunhofer Institute for Communication, Information Processing and Ergonomics have established an independent panel of experts who will help set ethical and internationally applicable legal guidelines for the FCAS.



"For the first time in the history of Germany, a major defense policy project is accompanied from the start by the intellectual struggle for the technical implementation of basic ethical and legal principles—ethical and legal compliance by design," says professor Reimund Neugebauer, president of the Fraunhofer Society.

The panel is calling for the human to remain in the loop of an FCAS engagement process, even in a high-workload environment, a point stressed by Brig. Gen. Gerald Funke, Germany's FCAS program leader. Germany, he says, would not accept a "technical interpretation that would allow a system to have another human being killed simply by computing an algorithm."

"Fighting at machine speed is accompanied by a real risk of escalation. So it is prudent that we keep humans as circuit breakers," Frank Sauer, a senior researcher at the University of the Bundeswehr [German Armed Forces] in Munich told a virtual meeting of the panel on May 14. "From an ethical point of view, delegating kill decisions is unacceptable and goes against fundamental human values . . . including the principle of infringing on human dignity. If Europe gets it right, this could be sending an important signal to the rest of the world," he added.

Findings from the forum will feed into the development of the system, Airbus FCAS Chief Engineer Thomas Grohs told the forum.

Currently, the design of the system is driven by "rules of engagement and concepts of operations," influenced by technical, legal and safety requirements, Grohs said. "But I have very limited requirements, which are driven by ethical requirements," he added. One of the challenges, he suggested, could be the development of a flexible neural network that could be trained about behaviors that may differ among different users.

He said there would need to be "decisive break points" in the process of sensing a threat, selecting an effect to deal with the threat and then conducting the engagement. But those requirements, Grohs said, still need to be "plotted out."

Work is also underway to better understand the role of the human in the cockpit. That role will be complicated by the need to operate and monitor the activities performed by the remote carriers rather than just flying the fighter.

Questions remain about what the autonomous systems would do when cut off from the wider network cloud, perhaps through jamming or hacking: Should they go on to complete the mission with their original instructions based on rules of engagement or pause and wait until communication can be reestablished, by which time fleeting time-sensitive targets may have escaped? Similar questions are being asked by the U.S., which has proved through its Have Raider 2 studies that unmanned platforms could perform a strike mission autonomously, with onboard sensors used to identify a target and release weapons to strike it.

And will the other FCAS nations follow in Germany's footsteps?

Significant differences already exist in the operating doctrines between Germany and France, and the same goes for their approaches to the use of autonomy in AI and warfare.

"The divergences between France and Germany are amongst the most pronounced in Europe. All of this is in flux. At the moment, France appears more open to autonomy and AI in warfare and Germany more cautious," says Ulrike Franke, a military technology expert with the European Council on Foreign Relations.

"One of the challenges for the FCAS project will be how to reconcile these positions," she adds.

Development of the FCAS is moving forward. In early May, the German, French and Spanish air chiefs agreed on the operational criteria for judging the planned combination and balance of fighters and remote carriers, with a final decision expected to emerge in mid-2021 at the conclusion of conceptual studies. Demonstrators of the future fighter, its engine and the remote carriers will take to the air in 2026.

REACHING OUT

> AIR-TO-AIR WEAPONS DEVELOPMENT CAPABILITIES HAVE PROLIFERATED IN THE LAST 25 YEARS

> NEW TECH TAPPED TO DRIVE UP PROBABILITY OF KILL

Tony Osborne London

PART 1 OF 2

THE MODERN AERIAL engagement is a complicated, high-stress environment. In a modern air battle, speed is life and range essential. With fighters converging at up to 20 mi./min., there is little time to react.

Pilots must examine the air picture, develop a target plan and sort potential targets between his wingmen while simultaneously trying to understand the vulnerability of their foes.

Long before the missile is unleashed from the rail, it will have been shaped not only by the threats it will face but by the fleet size of the fighter to which it will be fitted—and even the weapon that came before it.

Air-to-air missiles have come a long way since the first iterations of the U.S. Sidewinder were developed by the U.S. Navy in the 1950s. Advances in seekers, warheads, fusing and propulsion have transformed performance and range, and the technology has proliferated. About 15 countries can now claim indigenous development. France, Israel, Russia, the UK and U.S., all pioneers of air-to-air missile technology, have now been joined by China, India, Japan, South Africa and Turkey.

Traditionally, development has focused on long- or short-range weapons, but these delineations have blurred in recent years. The ramjet-powered MBDA Meteor and the Chinese PL-15 have readjusted the view of what is long-range, meeting and potentially exceeding the performance of the AIM-54 Phoenix missile that equipped the Grumman F-14 Tomcat. Some within-visual-range weapons such as the MBDA Advanced Short-Range Air-to-Air Missile (Asraam) and French Mica, can now comfortably reach into the medium-range realm, while others such as the Raytheon AIM-9X and Israeli Rafael Python 5 are highly agile dogfighting missiles.

Low-observable fighters such as the Lockheed Martin F-35, pictured launching an AIM-120 Amraam, can increase PK by getting close to their targets, but they are compromised because they carry fewer weapons in their bays.

MASTER SGT. MICHAEL JACKSON/U.S. AIR FORCE

Regardless of your role as either aggressor or defender, range is a necessary ingredient of the modern aerial engagement. Distance provides safety for the fighter and more opportunities to reengage if a missile fails.

"You want to control the airspace you are operating in," explains an industry air-to-air missile expert. "The greater the range of your weapon, the fewer platforms you need to control the same amount of airspace."

That desire for greater range is arguably having a profound influence on the evolution of beyond-visual-range air-to-air missiles.

Modern fighters are capable of high-performance maneuvering, so any missile developed to defeat them must be able to maneuver in the final moments of the engagement. So the aim of missile engineers is to increase the weapon's probability of kill (PK). The higher the PK, the fewer missiles will have to carried. PK is directly influenced by probability of fuse (PF), the activation of the weapon fuse when it hits or gets close enough to the target to activate. The probability of guide (PG) also influences how the weapon will find its way to the target. PF can be heavily influenced by the weapon's ability to react to maneuvering by the target.

PK can also be enhanced through the use of stealth. Low observability can help a fighter close in on its target and fire from much shorter ranges than its nonstealthy counterparts—but it is also compromised because it carries fewer weapons in its bays.

The air-to-air missile's biggest foe is physics. The higher its speed, the better chance it has of maneuvering with its small control surfaces. But once its propellent is used up and the motor burns out, air resistance begins to slow it down. Extending range or boosting energy has prompted investment in the development of new propellants, dual pulse motors that can provide a kick in the final moments of flight and adjusted flight profiles. In the case of MBDA's Meteor, a throttleable ramjet keeps the missile propelled to the end game; its true range is classified.

PK can also be influenced by firing more than one missile, or even salvos, at a target. Russian doctrine for example, according to Justin Bronk, an airpower and technology research fellow at the London-based Royal United Services Institute, calls for the firing of multiple missiles with different seeker heads at a target to increase the PK.

"The Russians want to be able to fire 3-6 missiles with a mix of seeker types at a single target, which is why aircraft like the [Sukhoi] Su-27 are able to carry 10-12 missiles," Bronk notes. In the salvo will be infrared-guided, radio-frequency (RF)-guided and anti-radiation guided missiles, the latter

able to home in on jamming signals, challenging the defending aircraft to tackle all three.

In the West an RF or radar-seeker is preferred for long-range engagements because of the all-weather performance of the sensor. After all, the pilot has no idea what the weather is like at the other end of the engagement. Before the introduction of Raytheon's Advanced Medium-Range Air-to-Air Missile (Amraam), its predecessors such as the Italian Aspide, British Skyflash and U.S. Sparrow used semi-active seekers, relying on the launching fighter to keep pointing its radar at the target aircraft. The missile would then home in on the reflected returns.

The use of active seekers such as that on the AIM-120 Amraam and increasingly active, electronically scanned arrays like on the Japanese AAM-4B, means the launching aircraft can turn away from the target once the weapon is active, and the pilot can then turn his attention to another target.

Increasingly, fighters can communicate with their weapon inflight through data links, allowing the aircraft's radar to update the weapon's radar on the position of the target. This may happen several times during an engagement, but this bond between fighter and radar is cut once the aircraft turns away, a process known crudely by some pilots as the "snip."

Some data links are one-way only, but Western OEMs are increasingly adopting two-way systems, allowing the missile to send data back to the pilot, helping the pilot understand the weapon's status, whether it is working or if there is a need to deploy more of them.

Missile manufacturers employ a range of fusing techniques, but on longer-range weapons will often use RF-sensing fuses for the same reason they use RF-seekers: because the conditions at the target are uncertain. Few missiles are hit-to-kill; instead the fusing triggers blast fragmentation warheads that pepper the target with shrapnel, damaging fragile parts of the aircraft.

Other missiles make use of continuously expanding rod warheads that once detonated expand rapidly into a ring pattern and create damage through a cutting action that can slice through control surfaces. Warhead size can have a significant influence on PK: Some weapons are equipped with large warheads, but maneuverable missiles that can get close to the target could use a smaller warhead to achieve the same effect.

While a fighter pilot will generally prefer to engage from range, there will likely always be a need to engage targets in the within-visual-range arena. Such scenarios pose greater risks, as they bring the enemy aircraft into closer proximity. Shorter-range air-to-air missiles are generally equipped with infrared seekers, giving additional spectrum options for the fighter and providing some redundancy for RF-guided weapons in the event of a system failure.

MBDA's Asraam was developed to operate in the transition range between the beyond-visual-range and within-visual-range regimes. It is used by Australia, India and the UK.

GEOFF LEE/MBDA

There are two approaches to the within-visual-range regime. Weapons such as the British Asraam, the French Mica and more recently the South African A-Darter have focused on engaging aircraft in the transition from beyond visual range to within visual range. All three use large rocket motors and propellent loads to accelerate the missile quickly off the rail to score the kill before a dogfight situation occurs. Such quick reaction times are often possible due to onboard systems such as batteries to prime the seeker head.

A look at the PL-10 missile suggests the Chinese may have taken a similar approach, missile experts indicate.

Weapons such as the AIM-9X and the Python family of missiles are considered more close-in dogfight weapons. Such weapons use their control surfaces and systems such as thrust vectoring to achieve high agility against maneuvering targets.

"Israel tends to prioritize agility and seeker performance for their shorter-range weapons because their targets are often small UAVs and cruise missile type threats," says Bronk. "They need good performance against small targets flying low."

Dogfighting presents its own dangers. In entering one-on-one combat, each pilot is trying to gain the upper hand in a minimum-range fight. "Your situation awareness decreases to that opponent. This is the highest risk," says the former Royal Air Force pilot. "You are either going to run out of fuel or get shot down by [the enemy's] wingman."

While combat aircraft such as the F-14 were built around the Phoenix missile and a specific threat—tackling Soviet long-range bombers over the Atlantic—the longevity of fighters today means they will be integrated with several missile types throughout their operational life. But the cost of integration, often in part due to complex flight control systems, means that increasingly the shape of these more capable weapons is being predicated on that of their predecessors.

The Eurofighter Typhoon, for example, features semirecessed missile stations that were sized for the Amraam. That constraint limited the dimensions of the MBDA Meteor, while in France the new Mica NG is being developed to keep to the same aerodynamic mass and center of gravity as the current version. The Lockheed Martin AIM-260 currently under development is expected to keep a similar form factor to the AIM-120, U.S. Air Force officials have said, in part to support its fitment into the bay of the F-22 Raptor.

Red Air Rumble

Lee Hudson Washington

SENIOR AIRMAN CASSIDY WOODY/U.S. AIR FORCE

The U.S. Air Force is significantly expanding its contractor adversary air services so that military fighter pilots can focus on their primary mission and hone their electronic warfare skills.

HISTORICALLY, THE AIR FORCE HAS kept its adversary air capability in-house. But in times of declining defense budgets, it began to turn to industry for support because companies offered the service at a lower price point.

In 2019, Air Combat Command (ACC) awarded five-year contracts, with options to extend an additional five years, to seven companies, allowing those vendors to bid on specific task orders for the Combat Air Force (CAF) Contracted Air Support (CAS) program. Bids were due for the first round of awards on March 31 for a total of six bases, and the Air Force anticipates announcing the winners imminently.

Air USA, Airborne Tactical Advantage Co. (ATAC), Blue Air Training, Coastal Defense, Draken International, Tactical Air Support and Top Aces Corp. are the only potential awardees.

"In accordance with ACC's priorities to support fighter pilot production, all selected operating locations encompass a majority of the fourth- and fifth-generation fighter aircraft Formal Training Units (FTU)," Air Force spokeswoman Leah Garton told Aviation Week in a May 18 statement. "Warfighter requirements as [they pertain] to bolstering production and readiness, along with anticipated funding levels, will determine future CAF/CAS operations."

The prospective operating locations include Eglin AFB, Florida; Holloman AFB, New Mexico; Kelly Field, Texas; Kingsley Field ANGB, Oregon; Luke AFB, Arizona; Nellis AFB, Nevada; and Seymour Johnson AFB, North Carolina.

"Sortie support quantities at each operating location are calculated on the current requirement from the user and have already been factored in to the base year execution plan," Garton explains.

Draken International: L-159

DRAKEN INTERNATIONAL

Contracting adversary air support is not new for the U.S. military. The Navy pioneered the concept for the Defense Department, opening the door for the other services. Section 350 of the 2017 National Defense Authorization Act directed the Air Force chief of staff to develop a plan for an "improved and dedicated adversary air training enterprise."

The law requires the Air Force to demonstrate commitment to the endeavor through its policy decisions, resource allocations, partnerships with other U.S. armed services and with allies, and its use of industry-contracted services.

After the Air Force determined its adversary air enterprise could use contractor support, the service disclosed which aircraft attributes are most coveted at its various bases,

Draken employees signaled a 58th Fighter Sqdn. hand sign as an L-159 Honeybadger taxied the flightline.

to help industry make informed decisions when bidding on task orders. At Nellis, the service is weighing active and passive detection as the top attributes. Active and passive detection are more important than aircraft turn, speed and altitude; however, speed and altitude performance are substantially more important than turn performance to support visual-range employment.

In 2015, Draken secured an adversary air support contract with the Air Force at Nellis to fly Douglas A-4K Skyhawk and Aero Vodochody L-159E ALCA fighters outfitted with modern radars and electronic attack pods. That was the first time the Air Force used commercial adversary support, and the idea was to support the weapons school. In June 2018, Draken was awarded another contract to perform the adversary air work through December 2023. The company has introduced Dassault Mirage F1s into the mix at Nellis and now operates 30 aircraft at the base, making it the largest flying organization there.

Draken can support up to 10 bases under the Nellis contract. To date, the company has supported Davis-Monthan, Arizona; Eglin; Eielson, Alaska; Hill, Utah; Holloman; Kingsley Field; Luke; Mountain Home, Idaho; and Seymour Johnson AFBs. Once the agreement expires, the service may decide to compete the Nellis work under the CAF/CAS contract.

The service considers passive detection the top attribute for supporting fifth-generation fighter training units at Eglin and Tyndall AFBs, Florida, and fifth-generation operational units at Joint Base Langley-Eustis, Virginia; Hickam AFB, Hawaii; and Hill AFB, Utah. The Air Force weights active detection as more important than aircraft turn, speed and altitude. These

Tactical Air Support: F-5

TACTICAL AIR SUPPORT INC.

bases rank speed and altitude higher than turn performance to support beyond-visual-range employment.

For fourth-generation fighter training units at Holloman, Kelly Field, Kingsley, Luke, Seymour Johnson and Davis-Monthan, the top attribute is active detection, which is considered more important than aircraft turn, speed and altitude. Aircraft turn, speed and altitude are all more important than passive detection to support air combat maneuvering training.

The Air Force defines active detection as the ability to track "Blue" aircraft at beyond visual range with a radar, but the company must also provide an emitter that replicates and substitutes for radar capability.

For the CAS part of the equation, the Air Force determined that tactically relevant aircraft include Aero L-39, L59 and L-159E; Aermacchi MB-339; BAE 167 Strikemaster; Dassault Mirage F1; Dassault/Dornier Alpha Jet; Embraer A-29, IAR-823; McDonnell Douglas A-4 Skyhawk; North American Rockwell OV-10; Leonardo SF-260; Textron AT-6; and Shorts Tucano.

"The government's intent is not to replicate fielded [Defense Department] platforms, only air-to-ground capability to fulfill a training gap for ground personnel," the solicitation states.

Once the Air Force awards the initial round of task orders, companies will have 12 months to begin adversary air support.

"The Air Force need is immediate, [and] we have the resources to continue supporting all of these different bases depending on who wins and how long it takes them to get mobilized and set up," Scott "Kidd" Poteet, Air Force programs director at Draken tells Aviation Week. Draken submitted bids for all six task orders, he adds.

Another company bidding on the task orders, Tactical Air Support, supplies the Navy with adversary air support. The company has 25 F-5s, a mix of CF-5Ds, Es and Fs providing fourth-generation adversary air contract services for the Navy at NAS Fallon, Nevada. The company is also supplying close air support under contract for the Marine Corps.

Tactical Air Support is modifying its fleet of F-5s with modern avionics to meet both ACC and Navy requirements at its facility in Reno, Nevada. For example, the company is installing the Garmin G3000 integrated flight deck that fuses data onto a display similar to those of the F-22 and F-35, Mick Guthals, ACC CAF/CAS program manager at Tactical Air Support tells Aviation Week.

Airborne Tactical Advantage: Mirage F1

ATAC

In 2017, ATAC purchased Mirage F-1 aircraft that it put forward for the ACC adversary air support competition. The company is partnered with another vendor to offer A-27s for the CAS portion of the contract because Air Force Special Operations Command has "gravitated a bit toward the A-29, and we think that the A-27 provides a nice capability," Michael "Moses" Thompson, Air Force programs senior manager at ATAC tells Aviation Week.

Top Aces: F-16

TOP ACES

ATAC has an extensive history supporting the Navy with adversary air services but was underbid by Tactical Air Support in the latest round of the competition, which ended with the Government Accountability Office denying the company's bid protest.

Another company vying for work with ACC, Top Aces, has an extensive overseas presence in Canada and Germany and was previously conducting work for Australia. Top Aces has a signed sale agreement for 29 F-16s and is in the final stages of getting third-party transfer approval from the State Department. The company invested $7 million for structural upgrades and avionics improvements to make sure the jets are up and running once they arrive in the U.S., Russ Quinn, Top Aces Corp. president tells Aviation Week.

The plan is to load the F-16s into an aircraft and fly them to the U.S. for the open mission system architecture work, Quinn says.

Illinois-based Air USA has reached an agreement with Australia to purchase its remaining 46 F/A-18 A/B Hornets. The Hornet will be retired from the Royal Australian Air Force by the end of 2021 to make room for the F-35A. The company did not respond to a request for comment. It remains unknown how Air USA would import and modify the F/A-18s within the CAF/CAS contract's 12-month window.

The ACC's CAF/CAS contract is not the only Air Force adversary air support contract on the horizon. The service is exploring future industry opportunities in the adversary air space. U.S. Air Forces in Europe (USAFE) is conducting market research for adversary air support requirements at multiple locations in the area of responsibility.

Aviation Week confirmed four of the companies participating in the CAF/CAS contract are interested in supporting the Air Force with adversary air services in Europe. The remaining three companies did not respond to a request for an interview.

The call to industry is intended to inform a performance work statement for USAFE. The government anticipates the requirement will be planned for up to five years: one base year and four option years.

"The contractor's responsibilities shall consist of operations, maintenance and performance of tactically relevant aircraft for air-to-air tracking, targeting, and adversary air support operations, to include equipment systems that interface with various platforms and ground force personnel," the notice says.

U.S. Air Force Moves Put 1,000 Engines Up for Grabs

> F-15EX PROGRAM STARTS MARKET RESEARCH ON F100

> SOURCE SELECTION PHASE STARTS FOR B-52 REENGINING

Steve Trimble Washington

More than 1,000 military engines could be in competition after two recent moves by U.S. Air Force acquisition officials.

Facing legal pressure from Pratt & Whitney, the Air Force agreed to perform a market survey for engine options to power the Boeing F-15EX after the first production lot, which potentially opens the door to a competition between Pratt's F100-PW-229 and the GE Aviation F110-GE-129.

The Air Force also initiated the second phase of a source selection process for the B-52 Commercial Engine Replacement Program (CERP), which seeks to acquire 608 modern turbofans and spares to replace the aging Pratt TF33 on each of the eight-engine bombers over the next 15 years.

In a U.S. military aviation market with few orders up for grabs, engine manufacturers GE, Pratt and Rolls-Royce are entering what could be an industry-defining period of competition. Pratt has a clear lead over its rival with sole-source positions as the propulsion supplier for the Air Force's Lockheed Martin F-35A fighter, Northrop Grumman B-21 bomber and Boeing KC-46 tanker. But Pratt's competitors have scored major wins in the last two years with the GE F404 selected to power the Boeing T-7A trainer and Rolls' AE3007 set to be installed on the Navy's Boeing MQ-25As.

Seeking to introduce the F-15EX as quickly as possible and replace aging F-15Cs, the Air Force initially decided to forgo a competition for the engine. Although Pratt's F100-PW-220 and -229 are the only powerplants on the Air Force's F-15E fleet today, GE's F110 is the only engine qualified on a configuration that includes two major updates for the F-15EX, which comprise a fly-by-wire control system and a redesigned wing.

The first F-15QA prototype completed a first flight in April, with GE F110 engines powering a vertical climb on takeoff.

Pratt still struggled to decide how to react after the Air Force published a notice of intent in late January to award the sole-source engine contract to GE. "There were some long days in February and late January when we were trying to decide if this is something that we want to protest," says Mark Beierle, Pratt's F100 program director. "But you just want to be a part of the competition. We think we have a legacy with the program. We have a very viable engine."

In response to the sole-source decision, Pratt submitted a capabilities statement to the Air Force about the F100 and filed a protest with the Government Accountability Office in hopes of forcing a competition. Ultimately, the Air Force decided to meet Pratt halfway. The GAO dismissed the company's complaint in March, and the Air Force has launched a market research study. The first lot of engines for eight F-15EX fighters procured in Lot 1 will be awarded to GE, but the study will consider the readiness of the F100 to compete for future production lots.

"We believe that a fair opportunity to compete is the best thing for the warfighter," says Kinda Eastwood, Pratt's executive director for integrated customer solutions.

By contrast, a healthy competition is underway for the B-52 CERP contract. Four engines—GE's CF34-10 and Passport powerplants, Pratt's PW800 and the Rolls-Royce BR.725, which is marketed to the Air Force as the F130—are competing for the order. All three companies submitted virtual prototypes of the engines and completed an integration risk analysis with Boeing in Phase 1 of the competition. The Air Force now has initiated the Phase 2 source selection process, with final bids due in July.

The Air Force prizes bids that can deliver more fuel efficiency than the minimum requirement, with pricing credits worth up to $375 million available for more fuel-efficient engines. Pricing credits worth up to $125 million also are available for engines that exceed the Air Force's threshold requirement for unscheduled engine removals.

The challenge will be to adapt a modern engine to the mounts, pylon structure and avionics of the B-52. By selecting an eight- rather than a four-engine replacement configuration, the Air Force minimized changes to the wing structure and the need to adapt the rudder to overcome greater adverse yaw caused by an outboard engine failure. But the introduction of modern engines with full-authority digital engine controls has driven a requirement to update the avionics displays in the cockpit.

Libya's Little Green Jets

- RUSSIAN JETS REPAINTED TO HIDE THEIR ORIGIN
- AFRICOM BELIEVES MIG-29s AND SU-24s IN LIBYA ARE BEING FLOWN BY MERCENARIES

Tony Osborne London and **Steve Trimble** Washington

The arrival of Russian combat aircraft in Libya is prompting concerns of an escalation in the battle for control of the bloodied North African state.

The U.S. fears that advanced ground-based air defenses could be next to arrive as tensions ratchet up between the internationally recognized Government of National Accord (GNA) and the Libyan National Army (LNA) led by Field Marshal Khalifa Haftar and backed by Egypt, Russia and the United Arab Emirates (UAE).

Open-source intelligence and commercially available satellite imagery revealed that MiG-29 "Fulcrum" fighters and Sukhoi Su-24 "Fencer" fighter-bombers transited from Syria to Libya around May 18, with the MiG-29s landing at the LNA-controlled Al-Jufrah Air Base, some 140 mi. southwest of the Libyan city of Sirte. The images showed one of the MiG-29s being towed along a taxiway following its arrival.

Both sides have used aircraft that formed part of the Libyan Air Force's inventory, but because the MiG-29 was never previously flown by Libya, the type's presence is considerably more conspicuous. Suspicions were finally confirmed when U.S. Africa Command (Africom) released its own imagery of the Russian fighters en route to Libya on May 26. As many as 14 aircraft may have been delivered to Libya, Africom sources tell Aviation Week.

"For too long, Russia has denied the full extent of its involvement in the ongoing Libyan conflict," Gen. Stephen Townsend, commander of Africom, says in a statement. "Well, there is no denying it now. We watched as Russia flew fourth-generation jet fighters to Libya—every step of the way."

Gen. Jeffrey Harrigian, commander of U.S. Air Forces in Europe and Africa says "The next logical step is [the Russians] deploy permanent long-range anti-access/area denial capabilities. If that day comes, it will create very real security concerns on Europe's southern flank."

Harrigian's warning suggests Africom is concerned that Libya could become Russia's next overseas target—after Syria—for a more permanent military presence. In 2015, Russia deployed fighters and bombers to Khmeimim Air Base in Syria to support forces loyal to Syrian President Bashar al-Assad. But when one of the Su-24s was shot down by a Turkish Air Force F-16, Russia deployed the S-400 integrated air defense system to the country, complicating the already congested military airspace.

Haftar's forces have already managed to secure access to Pantsir self-propelled air defense systems, likely supplied by the UAE. According to Africom, the Pantsirs are likely operated by the Wagner Group, a Russian private military contractor that Moscow may be using to conceal its role in the conflict. Wagner's operatives will probably operate the fighters, too, Africom asserts.

Deployment of the fighters was likely prompted by recent successes on the battlefield for GNA forces. The LNA, while already in control of much of Libya, had come close to seizing control of the capital, Tripoli, earlier this year but was forced to pull back after Turkey intensified its support of the GNA.

U.S. AFRICA COMMAND

This early-model MiG-29, with Russian national markings scrubbed, is one of four caught by U.S. forces en route from Syria to Libya in May.

In May, the GNA captured the strategically important Al-Watiya Air Base, while an air campaign by Turkish-operated Bayraktar TB2 armed unmanned aerial systems destroyed as many as nine Pantsirs in 72 hr., according to the Clash Report, a social media news outlet with ties to Turkey. The GNA's gains prompted Haftar to announce his forces would "unleash the largest aerial campaign in Libyan history," with a focus on Turkish targets. Reports suggest a Turkish-flagged ship in waters off Tripoli was attacked by a MiG-29 on May 26.

Images released by Africom appear to show MiG-29s and Su-24s en route from Russia to Syria, where the aircraft made a stop at Khmeimim. According to Africom, the MiG-29s were hastily repainted at Khmeimim "to camouflage their Russian origin" before taking off again for Syria. Russian Air Force Sukhoi Su-35 "Flankers" may have escorted them part of the way. Africom has not said how the imagery was secured, but it appears to suggest that U.S. and coalition assets were shadowing the Russian aircraft from a distance with electro-optical cameras during both legs of the deployment.

Meanwhile, imagery published online on May 26 appears to reveal the presence of the Su-24s at the Al-Khadim Air

Base near Benghazi. The images show the aircraft parked under rudimentary shelters.

Additionally, the U.S. has also expressed its concerns about repeated unsafe and unprofessional intercepts by Russian combat aircraft on maritime patrol aircraft. According to the U.S. Navy's Sixth Fleet, one of its Boeing P-8 Poseidons operating in the Eastern Mediterranean Sea was intercepted on May 26 by two Russian Su-35s for more than an hour. The close encounter restricted "the P-8A's ability to safely maneuver," the Navy says. "The unnecessary actions of the Russian Su-35 pilots were inconsistent with good airmanship and international flight rules and jeopardized the safety of flight of both aircraft," Navy officials say.

LUFTHANSA TECHNIK

Other NATO nations are not planning to follow the U.S. exit from the Open Skies Treaty, so these camera apertures on Germany's new Airbus A319 observation platform will continue to be used.

How the U.S. Open Skies Exit Could Undermine Arms Control

> U.S. CITES RUSSIAN NONCOMPLIANCE AS RATIONALE FOR WITHDRAWAL

> U.S. AIR FORCE OC-135 FLEET MODERNIZATION PLAN HALTED

Tony Osborne London and **Jen DiMascio** Washington

The decision by the U.S. government to withdraw from the Open Skies Treaty signed two decades ago is creating ripples of discontent within the U.S. and in Europe.

Washington announced on May 22 that it would end its obligations to the arms control treaty in six months, saying that it was "no longer in the United States' best interest to remain a party to this Treaty when Russia does not uphold its commitments," in a statement put out by the Defense Department.

The Open Skies Treaty permits its 34 signatories to conduct observation flights over each other's territory. Aircraft with four types of sensors—optical panoramic and framing cameras, real-time video cameras, infrared line-scanners and sideways-looking synthetic aperture radar—may make observations anywhere over a country's national territory. Treaty rules say that the flight may only be restricted for reasons of flight safety, not for reasons of national security.

NATO and European nations may share U.S. concerns about inconsistent flight restrictions imposed by Moscow but see a U.S. departure from the agreement, in place since 1992, as regrettable.

According to the U.S. and NATO, Russia has imposed restrictions on the treaty, in particular those flying near Kaliningrad, Russia's enclave on the Baltic Sea, and near the country's border with Georgia. The Pentagon also says Moscow blocked the overflight of a major military exercise in September 2019, "preventing the exact transparency the treaty is meant to provide."

In an op-ed in *The New York Times*, Tim Morrison, a senior fellow at the Hudson Institute and a former member of this administration's National Security Council, added that Russia has been using its overflights to collect "military relevant intelligence on the other parties, like the means to target critical infrastructure."

NATO Secretary General Jens Stoltenberg, during the May 22 meeting of alliance members, called on the Russian government to return to compliance as soon as possible, noting that the U.S. could reconsider its position if Russia complied.

European Open Skies Treaty member states—including Belgium, the

Czech Republic, Finland, France, Germany, Italy, Luxembourg, Netherlands, Spain and Sweden—said they would continue to implement the treaty, saying it has a "clear added value" for conventional arms control architecture and cooperative security.

Russia rejects the claims of flight restrictions and contends that the U.S. had limited Russia's own Open Skies flights over Hawaii and the Aleutian Islands. Senior Russian officials, including Dmitry Medvedev, deputy chairman of the Russian Security Council, denounced Washington's decision. Medvedev said the U.S. had taken another step down the "path of dismantling the international security architecture that took decades to lay down."

Moscow believes Washington's decision could also affect other arms control treaties, with negotiations on the next New Strategic Arms Reduction Treaty potentially at risk.

In Washington, the leaders of the House Armed Services and Foreign Affairs committees (both Democrats) have written a letter to Defense Secretary Mark Esper and Secretary of State Mike Pompeo contending that withdrawal from the treaty is illegal. They say it violates the fiscal 2020 National Defense Authorization Act, which requires Esper and Pompeo to notify Congress 120 days before the intent to withdrawal is presented.

"This notification must be based on your joint conclusion that withdrawal is in the best interests of the United States and that other states parties to the treaty have been consulted. To date, this requirement has not been fulfilled," wrote Reps. Adam Smith (Wash.), the Armed Services chairman, and Eliot Engel (N.Y.), the Foreign Affairs chairman.

President Donald Trump and his administration have support from Republicans who lead the Senate for their decision to exit the treaty.

Sen. James Inhofe (R-Okla.), who chairs the Senate Armed Services Committee, asserts that the U.S. should withdraw if Russia is not complying with the agreement. "It will be critical for the Trump administration to continue working with our allies and partners, especially those in Eastern Europe, to ensure they have access to the intelligence they need to protect their security. That includes facilitating access to high-quality imagery."

The U.S. had planned to upgrade the two Boeing OC-135 aircraft delivered to the Air Force in 1996. Late last year, the U.S. issued a request for information saying it was considering awarding two contracts—one for the purchase of two commercial aircraft and another to modify the airframe and provide logistics support. But the Pentagon did not include funding for OC-135 upgrades in its fiscal 2020 budget request. And in March, Esper told Congress he was not prepared to authorize funding for those upgrades until a path forward is clear.

Several signatories to the treaty have dedicated aircraft for the mission, others share or lease platforms from other nations for the task. Germany is the latest country to dedicate an aircraft for the mission, using an Airbus A319 converted by Lufthansa Technik.

A GIANT IN THE MAKING

IGA

> ISTANBUL'S NEW AIRPORT PROJECT TARGETS SIX RUNWAYS

> EUROCONTROL SIMULATION IS KEY IN ROUTE NETWORK DESIGN

> GROUND TRAFFIC PROBLEMS ARE BEING SOLVED, TOO

Thierry Dubois Lyon

From the top floor of a cobra-shaped tower at Istanbul Airport, air traffic controllers handling runway traffic have a bird's-eye view of the intricate trajectories they instruct aircraft to follow to and from the gates.

The two existing parallel runways already create challenging situations on the taxiways, such as difficult crossings and traffic jams, and the airport is planned to expand to six runways. To deal with that entire situation, a combination of operational feedback and simulation is being used to validate the route network (on the ground and in the air) before each new stage in the airport's expansion.

During construction, trucks moved the equivalent in volume of one Egyptian pyramid of earth per day. In operation since April 2019, the first phase comprises the two parallel runways and a terminal with a passenger capacity of 90 million per year. Once complete, the new airport is envisaged to host flights to more than 300 destinations with an annual capacity of 200 million passengers (twice that of Hartsfield-Jackson Atlanta International Airport), possibly making it the busiest airport in the world.

Once complete, Istanbul Airport is envisaged to host flights to more than 300 destinations. Of the six planned independent runways, the first two are visible left of the passenger terminal (center); the third one is on the right.

One dimension of Istanbul Airport does not lend itself to representation by numbers: the complexity of ground, approach and initial climb trajectories. Controllers and air traffic management (ATM) experts are devising them in a simulation room in Bretigny, near Paris. Turkey is a member state of Eurocontrol, the organization in charge of ATM in Europe, and so benefits from its research and development (R&D) capabilities.

The process epitomizes the knotty task of building an air traffic architecture around a new, giant hub.

In 2017-18, Turkish controllers spent six weeks in Bretigny for a two-runway simulation. Routes had to connect with those around two other Istanbul-area airports, Ataturk and Sabiha Gokcen, says Michel Geissel, real-time simula-

tion project manager at Eurocontrol. Distances between the three airports are in the 20-40-nm range.

Ataturk had been Istanbul's main airport but became congested; it is now focused on business aviation and cargo flights. Sabiha Gokcen serves touristic destinations and the eastern Istanbul metro area. To complicate matters, a second runway is to be introduced at Sabiha Gokcen.

Connecting with the routes of neighboring countries' airspace must also be factored in, Geissel says.

During the simulation session in 2017-18, approach and departure route designs were validated for Istanbul Airport. Simultaneously, experts from Paris Charles de Gaulle Airport's control towers shared their experiences in operating two parallel, independent runways.

An ongoing simulation session is focusing on the addition of a third runway. It involves some 45 approach and tower controllers (the latter in charge of aircraft at or in the immediate vicinity of the airport) per week and is planned to last nine weeks. Six weeks of simulation were completed early this year, and the session will resume in September if the global health situation permits.

Once in operation, the third runway, located east of the terminal, will reduce domestic taxi times by approximately 50%, according to Istanbul Grand Airport (IGA), the company managing the airport. The average landing time will decrease to 11 min. from 15 min., while average takeoff time will drop to 15 min. from 22 min., IGA calculates. The new runway will increase the airport's capacity to 120 aircraft movements (takeoffs and landings) per hour from the current 80.

The first part of the simulation session also proved useful for tower controllers in solving congestion problems with the existing two runways. They could optimize taxiing times and radio frequency transfers, Geissel says. The exercise was built for three runways but beneficial to the two-runway configuration. It involved six controller positions and six pseudo pilots (controllers played the roles of pilots).

In addition to the taxiway maze, traffic must be handled on elaborate standard instrument departure (SID) and standard terminal arrival (STAR) routes. SIDs and STARs can be schematized as bunches of flowers at the end of each runway. At first glance, it would seem every aircraft taking a left turn after takeoff should use the left runway, and reciprocally a right turn after takeoff should be taken from the right runway.

But this could involve more crossings on taxiways. An aircraft at a gate on the right side of the terminal might have to use the left runway. "Controllers have to determine which configuration is best [:] crossings on the ground or in the air," Geissel says.

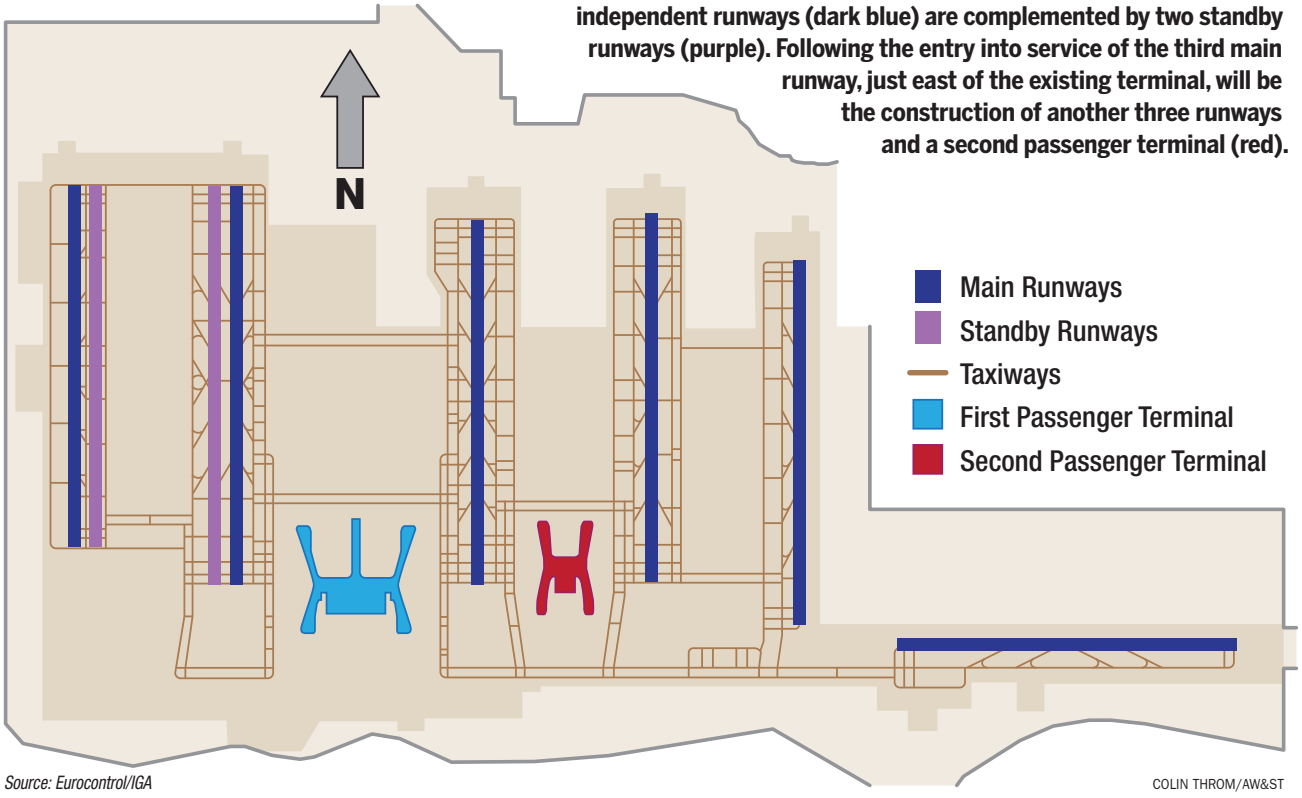
An additional twist is that each of the two runways can become a pair of parallel, interdependent runways. Each main runway has a parallel, standby runway alongside. During traffic peaks, all four can be used as runways—each pair then includes one for takeoff and one for landing.

The standby runways will later become taxiways as the number of main runways grows.

In designing routes to and from Istanbul Airport rather than Ataturk Airport, Turkey's ATM experts also had to study the impact on Bulgaria's airspace, north of Turkey's. The new airport is located north of the older

Istanbul Airport

Istanbul Airport, a 200-million-passenger project, has been operating with its first runways for one year. West of the main passenger terminal (light blue), two independent runways (dark blue) are complemented by two standby runways (purple). Following the entry into service of the third main runway, just east of the existing terminal, will be the construction of another three runways and a second passenger terminal (red).



Source: Eurocontrol/IGA

COLIN THROM/AW&ST

one, and the altitude at which a departing aircraft enters Bulgarian airspace is thus lower. Therefore, northbound aircraft taking off from Istanbul Airport could have created new conflicts with traffic flows in Bulgaria. "We had Bulgarian and Turkish controllers talking to each other," Geissel says.

In addition, the weather is different at Istanbul Airport. Due to its location on the Black Sea, prevailing winds are distinct from those at Ataturk, Geissel explains.

To organize the sequence of arriving aircraft for each main runway, "point merge" procedures were designed from the start (*AW&ST* July 29, 2013, p. 18). The idea is to have safe but minimal separation between aircraft on approach. The overarching goal is to make the most of the runway's capacity.

Moreover, so-called doglegs enable variable-length flightpaths. Depending on traffic density, an aircraft is instructed to detour via a waypoint or take a direct route. Because the entire area around Istanbul's three airports was redesigned in 2017-18, Sabiha Gokcen also has a point merge procedure.

It takes one year to prepare for an exhaustive simulation that will culminate with the validation of an airspace design, Geissel says. As a service provider, Eurocontrol needs the customer to send a "core team" of controllers that includes decision-makers and stays for the entire duration of the session.

A crucial phase in designing the airspace, its routes and associated procedures is making a detailed plan for the simulation. "Customers often have two or three high-level goals, and we have to ask them for details: Why are you here? What do you want to improve? . . . Our human factors experts are in charge of devising the experiment," Geissel says.

The final phase of preparation is about identifying issues that can arise only when controllers and pilots interact, Geissel says. They can typically be linked to aircraft performance or weather. In this early phase, numerous scenarios are tested and sometimes lead to finding 300 problems in one exercise, which eventually makes the simulation as realistic as possible, Geissel says.

During the main phase of the simulation, each scenario is usually run three times with different controllers. Each sector is staffed with two controllers under the usual framework—a planner and an executive controller. They are responsible for short-term planning and immediate action, re-

UNMANNED AIRCRAFT

Medical Drone Flights Demonstrate Confidence in BVLOS Operations

> THE FIRST ISLE OF WIGHT MEDICAL FLIGHT WAS COMPLETED ON MAY 9

> FLIGHTS ARE PART OF THE WIDER FUTURE TRANSPORT ZONE PROJECT

Tony Osborne London

Regular unmanned aircraft flights carrying medical supplies between the British mainland and the Isle of Wight are demonstrating that the UK is overcoming the regulatory and technical hurdles to making beyond-visual-line-of-sight (BVLOS) UAV flights routine.

The 13-min., 10-km (6-mi.) hop from Solent Airport, near Portsmouth, England, to the grassy airstrip in Binstead on the Isle of Wight barely tested the capabilities of the twin-engine Windracers UAV. But the first flight, which took place on May 9, was one of the first times a nonmilitary unmanned aircraft system was flown BVLOS in the UK.

The flights are in segregated airspace for now, but deconfliction plans are in place so that they do not disrupt airfield operations for other traffic.

The flights had been due to begin in 2021 but were accelerated in light of the novel coronavirus pandemic. They were moved ahead by UK Transport Secretary Grant Shapps, in recognition of the UAV's ability to transfer medical supplies quickly between the mainland and the Isle of Wight.

Such supplies would normally be transported across the Solent strait by ferry, but services are operating on a much-reduced schedule as a result of the pandemic.

The ULTRA UAV—for Unmanned Low-cost TRAnsport—the UK's heaviest nonmilitary fixed-wing UAV, was developed by the University of Southampton and funded by Windracers, a charitable organization looking to use UAVs to distribute humanitarian aid. The platform was designed to carry a payload of up to 100 kg (220 lb.) over a range of 1,000 km (620 mi.). Cargo is carried in a compartment the size of a car trunk, buried in the wing.

As of May 18, only one flight had been completed to the Isle of Wight, carrying pathology samples, but the team is set up to fly as many as 10 flights per day if required by the National Health Service. "This first flight has been invaluable in showing how the logistics at either end will have to operate to tie in with the drone operations," says Tom Cherrett, a professor of logistics and transport management at the University of Southampton.

"This will all contribute to the learning process of how such autonomous systems will function alongside traditional supply chains in the future," he adds.

So far, payloads have been restricted to 40 kg (88 lb.), in part because the UAV is carrying test equipment but also because the runway at Binstead Airfield is of limited length.

The next steps for the project are to expand the carriage beyond what the team calls "benign cargos," and it is working with the UK Civil Aviation Authority (CAA) to be able to carry medical samples, which are classified by the CAA as dangerous goods. The rules regarding carriage of such goods had not been applied to UAVs before. The team also plans to increase the range and fully automate the flight, including an automated landing and use of sense-and-avoid sensors. Current flights are performed using automatic takeoff but a semiautonomous landing. The team also has safety pilots at each airfield if needed.

The Isle of Wight demonstrations are operating under an £8 million ($9.7

spectively. A simulation involves real pilots (32 pilots for Istanbul Airport approach scenarios) from a third-party service provider.

In the simulation project, "it can be interesting to include controllers who are not convinced by the new design," Geissel says. They will experiment with the in-development procedures, and their feedback will be factored in, along with that of other controllers. "Simulations proved, on several occasions, to be a very good support to convince reluctant participants. . . . They will then become excellent champions," Geissel says.

Then comes a phase of Big Data analysis. Specifics such as controller workload (evaluated by the controller every 3 min.), cursor-control movements, the number of radio voice communications, the nature of the instructions given to pilots and answers to a final questionnaire are compiled.

One kind of interaction is not factored in, however. Controllers in different positions sometimes talk to one another, face to face. "We do not record this, but we accept it—after all, this is real life," Geissel says.

Debriefings are recorded to support the final analysis, too.

The analysis takes 1-2 months. It typically translates into 800 pages of results and a 50-page report. The most important page is the executive summary, which enables high-level decisions, Geissel says. "It includes comments such as: 'The airspace's architecture is consistent, but a slow climber might enter a military area.'. . . It is never black or white. Most of the time, it is white but with recommendations or limitations."

Eurocontrol calculates a maximum cost for the customer. In the end, the customer pays only for the work that was actually done. The amount may thus be less than the estimated maximum. "It helps [place the] focus on the designed solution, opening the door to improvements or moving faster to real-life implementation," Geissel says.

For an airport's ATM experts, coming to a foreign R&D center can be an opportunity to learn about new tools. Developed by Europe's SESAR Joint Undertaking for ATM research, the Leading Optimized Runway Delivery (LORD) tool reduces the buffer built in for controller intervention, thus increasing capacity. Meanwhile, LORD graphically helps the controller maintain separation. Istanbul Airport's representatives were interested, Geissel says.

SOLENT TRANSPORT

million) grant provided by the UK Transport Department but is part of a wider £28 million Future Transport Zone project to test mobility technologies in the Solent area, which includes the cities of Southampton and Portsmouth. If the UAV flights to the Isle of Wight are successful, other hospitals in the area could also be linked, likely by vertical-takeoff-and-landing systems. The work also calls for the development of a local air traffic management system, although work on this is not due to get underway until later this year and will involve several industrial partners, officials from the Southampton City Council tell Aviation Week.

The medical supply flights are one of several BVLOS flights now regularly taking place around the UK, as the government pushes for drone technology to be used more widely, both privately and publicly.

One government department is performing regular flights of a Portuguese-developed twin-engine Tekever AR5 UAV from Lydd Airport, Kent, England, to look for boats carrying migrants across the English Channel. The flights have been taking place since the end of 2019 but have been firmly kept out of the public eye. Meanwhile, the UK Maritime and Coastguard Agency is due this summer to fly a series of trial missions with Elbit Systems' Hermes 900 in support of search-and-rescue as well as antipollution efforts.

The ULTRA UAV is the heaviest fixed-wing nonmilitary UAV developed in the UK.

The Transport Department has since declared the Coastguard demonstrations a Pathfinder program, one of several UAV pilot projects designed to overcome the technical, operational and commercial barriers to BVLOS operations.

Elsewhere, unmanned-technology company Blue Bear is collaborating with Cranfield University on the National BLVOS Experimentation Corridor in Bedfordshire, England, where manned and unmanned vehicles share airspace. Meanwhile, the CAA has announced it will work with Boeing's future mobility business incubator through a memorandum of understanding that will explore requirements for detect-and-avoid systems and safety cases for BVLOS flights above 400 ft.

Walmart Executive Backs eVTOL Startup Archer

- DESIGN TEAM HAS SUBSTANTIAL eVTOL EXPERIENCE
- A LARGE-SCALE DEMONSTRATOR IS PLANNED TO FLY IN 2021

Graham Warwick Washington

An urban air mobility startup with an experienced design team and backing from a Walmart executive has emerged from stealth with plans to develop an all-electric vertical-takeoff-and-landing air taxi.

Palo Alto, California-based Archer is led by entrepreneurs Brett Adcock and Adam Goldstein and backed by Marc Lore, CEO of Walmart eCommerce. The design team includes engineers who worked on electric vertical-take-off-and-landing (eVTOL) development at Airbus Acubed, Joby Aviation and Kitty Hawk as well as at NASA and self-driving car developer Zoox.

ARCHER

The Archer eVTOL is a five-seat all-electric aircraft with "some tilting" to achieve performance goals.

Archer is developing a piloted eVTOL urban air taxi able to carry four passengers up to 60 mi. at 150 mph on today's battery technology. Details are not being released, but the design is a fixed-wing aircraft with 12 electric motors and "some tilting," says Adcock. A teaser image shows an aircraft with a V tail and six five-blade propellers on a high-aspect-ratio wing.

The startup hopes to set itself apart in the hype-plagued urban air mobility (UAM) market by tapping the experience of its design team to produce a safe, quiet vehicle with reliable performance at low manufacturing and operating costs.

Adcock and Goldstein sold hiring marketplace Vettery in 2018 for $100 million, while lead investor Lore sold his e-commerce company Jet.com to Walmart in 2016 for $3.3 billion. They are the latest internet entrepreneurs to put money into UAM. Google co-founder Larry Page backed Kitty Hawk while Pinterest co-founder Paul Sciarra co-founded Joby.

Archer is relatively late to the UAM game. "We are the underdog today, so we have a lot to prove," says Adcock. "The goal is for us to show the world that we can build a vehicle that is high-performance, with low direct operating costs, high safety and low noise."

The 44-strong team now "designing the perfect vehicle" is led by Tom Muniz and Geoff Bower. Muniz was previously vice president of engineering at Wisk, the Boeing/Kitty Hawk joint venture developing the Cora eVTOL. Bower was previously chief engineer on Acubed's Vahana eVTOL.

Archer has flown a number of subscale testbeds and is now building higher-fidelity models. In parallel, it is working on an 80%-scale demonstrator that is planned to fly in 2021. "It is too early to say when we will certify," says Adcock. "We need to start engaging with the FAA. We hope to certify in the most efficient way possible, but it will be a long journey."

Unlike some eVTOL startups that are counting on promised advances in battery technology to achieve their performance claims, he says Archer is designing "a vehicle that can get 60 mi. of range in the worse possible conditions." That means available batteries at the end of their useful life, with full reserves for emergencies and energy that is inaccessible due to low voltages.

"We think we can make that work today with technology that exists off the shelf," Adcock says. Archer is also designing for low noise for public acceptability. "We want these to be almost inaudible in flight over a city, operating at between 55 and 60 dB," Adcock says.

In addition to low direct operating cost, the startup is designing its eVTOL for low manufacturing cost. "The team we have has such a deep bench of knowledge we are hopeful we can home in on a design concept that can achieve the speed, range and payload we need to have an economically viable business. Also [we hope to achieve] the safety and noise levels to gain community acceptance and, at the same time, make sure we're focused on being able to mass-manufacture these vehicles," says Goldstein.

Archer is designing the eVTOL to the same 10^{-9} probability of catastrophic failure as commercial transport aircraft. "Safety is our No. 1 priority," adds Goldstein. "It's not just an Archer issue. As an industry, we need to make sure there is trust from the public and that we can get people in these vehicles right from the beginning."

Like other eVTOL startups, Archer is looking at both manufacturing and operating its air taxis. "If you can manufacture and operate, you have the best likelihood of providing the best possible customer experience, and that's something we're focused on," says Goldstein. "So that would be our aspiration. I don't think that precludes us from working with folks like Uber or a network."

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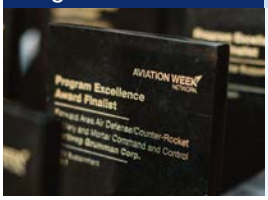

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AVIATION WEEK NETWORK

MagniX and AeroTEC Electrify Workhorse Caravan

- STCs PLANNED FOR BEAVER AND CARAVAN MODIFICATIONS
- 750-HP ELECTRIC MOTOR REPLACES PT6A TURBOPROP

MAGNIX PHOTOS

Powered by a 750-hp MagniX electric motor, the eCaravan lifts off from AeroTEC's test center at Moses Lake.

Graham Warwick Washington

Electric motor developer MagniX and certification specialist AeroTEC have flown a Cessna 208B Caravan converted to electric propulsion. The aircraft made a 30-min. first flight from Moses Lake, Washington, on May 27.

The eCaravan is the largest all-electric commercial aircraft to fly so far, and it follows a de Havilland Canada DHC-2 Beaver converted to electric propulsion by MagniX and Harbour Air Seaplanes that was first flown on Dec. 10, 2019.

The modified Caravan uses the same 560-kW (750-shp) Magni500 electric motor as that fitted to the eBeaver, but operating at a higher power output, MagniX CEO Roei Ganzarski says. The same power electronics and lithium-ion batteries are also used.

The Grand Caravan's 675-shp Pratt & Whitney PT6A turboprop and gearbox have been removed and a new mount installed for the smaller, lighter electric motor. This drives the existing propeller, providing the same power output as the PT6A.

As in the eBeaver, the batteries are mounted on the cabin floor of the test aircraft where they are accessible and can be monitored in flight, says Ganzarski. Other modifications include a pilot display for the electric propulsion system.

Using technology commercially available in 2019, the batteries are expected to provide 30 min. of flight time plus visual flight rules reserves, he says. This is projected to increase as lithium-ion batteries improve or other battery chemistries or energy sources such as fuel cells become available.

The eBeaver seaplane has flown for at least 30 min. in flight tests, "and we expect the same of the eCaravan," Ganzarski says. This equates to a roughly 100-mi. range. About 5% of worldwide commercial airline flights are less than 100 mi., he says, and this does not include small carriers such as Cape Air with short routes. "It seems short, but 100 mi. has great potential for subregional flight."

Flying both the eBeaver and the eCaravan allows MagniX to test its electric propulsion system "on water and on land, in cooler Vancouver and warmer Moses Lake," he says. The first phase of flight testing for both aircraft is expected to take 8-9 months, after which MagniX and its partners plan to begin supplemental type certification (STC) of the modifications.

The STC programs will take at least a year, he says, depending on the changes required to the aircraft. The batteries will have to be relocated to free up space in the cabin. Options for the eCaravan include mounting them in the wing or in the underfuselage cargo pod.

"We are starting out on the STC with the intent of making minimal changes" to minimize risk and cost, Ganzarski says. "We plan to maintain the structural design of the aircraft, and only work on where to put the batteries."

While the Magni500 motor produces the same power as the Caravan's PT6A, it provides more torque at lower propeller rpm, which enables a faster takeoff. The absence of any lapse in power with altitude, which happens in a turbine engine as density decreases, increases climb rate. Response to power changes is also much faster, he says.

Compared with the PT6A, the electric motor produces the same torque at lower propeller rpm, reducing noise while taxiing. At takeoff, the propeller noise is unchanged

but the turbine engine noise is absent. "At taxi it is almost silent," says Ganzarski.

Testing has also revealed that the Magni500 can produce greater maximum power in emergencies. MagniX estimated the motor could go 20% beyond its 750-hp continuous power rating for up to 10 min., but flight testing is showing "it can go to higher maximum power, and for a longer duration," he says. This would increase the performance margin in a twin-engine aircraft if one motor were to fail.

The eCaravan is a joint project by MagniX, led by MagniX CEO Roei Ganzarski (left), and AeroTEC, founded and led by Lee Human (right).

MagniX is also supplying its 280-kW Magni250 motors to power Israeli startup Eviation's 11-seat all-electric aircraft, the Alice. Both companies are owned by the Claremont Group, a Singapore-based investment conglomerate. Eviation's first prototype was damaged beyond repair in a fire during ground tests in January. A second prototype is on track to fly within 12 months, says Ganzarski, who is chairman of Eviation.

Due to the effects of COVID-19 on Eviation's customers, there has been "a slight slowing down" of the Alice program, he says. "There is no need to be in a hurry," he adds.

Ganzarski believes the novel coronavirus pandemic may actually have improved the prospects for electric regional aircraft. He says before COVID-19 there were two main drivers for electric aviation: the on-demand economy and need for low operating costs, and environmental awareness and demand to reduce emissions.

After COVID-19, Ganzarski believes small aircraft operating between small airports could become attractive to passengers wanting to travel shorter distances and keen to avoid the exposure of flying from hub airports in large aircraft.

The all-electric Alice has a design range greater than 500 mi., and almost half the airline flights in North America are under 500 mi., he says. "COVID could accelerate a return to small airports, and electric aircraft are exactly poised to take over."

U.S. Agencies Petition FCC Over Ligado License Order

> INDUSTRY GROUPS JOIN IN PETITIONING FCC

> AIRLINE PILOTS RAISE CONCERNS OVER SATCOM

BILL CAREY/AW&ST

A sign points the way to the Ligado Networks' headquarters in Reston, Virginia, outside of Washington.

Bill Carey Washington

Leading a pack of industry and government organizations in opposition, U.S. federal agencies formally petitioned an independent sister agency to reconsider its order allowing Ligado Networks access to radio frequency spectrum near frequencies allocated for GPS.

Representing the Defense Department, the Transportation Department and other executive branch agencies, the National Telecommunications and Information Administration (NTIA) petitioned the independent Federal Communications Commission (FCC) on May 22 to reconsider and stay, or postpone, its order granting Ligado use of L-band mobile satellite services spectrum to build a ground-based 5G cellular network.

The latter petition states that Ligado should not be permitted to deploy its network until federal agencies' concerns over its potential harmful effects on GPS devices are resolved.

A branch of the Commerce Department, the NTIA coordinates federal agencies' use of spectrum. Several aviation and other industry groups and manufacturers, including GPS Block III satellite manufacturer Lockheed Martin and L-band satellite communications (satcom) provider Iridium Communications have also petitioned the FCC to reconsider its decision.

"The impact of the FCC's decision is tantamount to permitting a deafening nuisance into a quiet residential neighborhood over the objections of affected neighbors," Lockheed Martin states its petition.

"Despite the strong concerns of and opposition from a wide array of private sector and government experts and stakeholders in this community, and a record replete with evidence that granting Ligado's proposal would cause harmful interference, the commission ignored material questions of fact, did not properly weigh the costs and benefits of Ligado's proposal, and offered a series of 'remedies' that are patently inadequate," the manufacturer adds.

The Air Line Pilots Association (ALPA) filed a petition for reconsideration of the Ligado decision on May 20, and a bipartisan group of 32 U.S. senators sent a letter to the FCC on May 15 asking it to reverse course. The bipartisan leadership and 20 members of the House Armed Services Committee (HASC) decried the "unacceptable risk" posed to GPS by Ligado's network in a May 7 letter to the commission.

The ALPA petition asks the FCC to disallow Ligado from operating transmitters at frequencies adjacent to the GPS band and in spectrum allocated for mobile satellite services at 1.6 GHz.

FAA-certified avionics are hardened against potential interference by a Ligado transmitter operating at a distance. The pilot union's concern is that general aviation pilots using tablet devices with uncertified GPS receivers to help them navigate, as well as small drones using uncertified receivers, are much more susceptible to interference, potentially causing them to blunder into the path of airliners.

The ALPA petition also raises the potential of Ligado-enabled smartphones carried by airline passengers interfering with L-band satcom used for controller-pilot data link communications and automatic dependent sur-

veillance-contract position reports—applications used by air navigation service providers to track and separate aircraft over remote and oceanic areas outside of radar coverage.

"If Ligado-compatible handsets were carried onboard aircraft by passengers and were to become active when satcom is being used for communications and surveillance, these safety services could potentially be disrupted," the ALPA petition argues.

Satcom providers Inmarsat and Iridium provide L-band satellite connectivity for critical aviation applications. In its 74-page order, the FCC states that Ligado has entered into an arrangement with Inmarsat to address potential interference concerns but not with Iridium.

"Absent an understanding between the parties, we reduce Ligado's emissions within the frequency band used by Iridium and encourage the parties to engage in further discussions to reach mutually satisfactory arrangements where possible," the commission's order states.

Senators wrote to the FCC following a May 6 hearing held by the Senate Armed Services Committee (SASC), which sought an explanation of the board's controversial 5-0 decision.

"A few powerful people made a hasty decision over the weekend in the middle of the [coronavirus] crisis against the judgment of every other agency involved and without clueing the president in on any of this," said Sen. James Inhofe (R-Okla.), the SASC chairman, in his opening remarks.

"They waited until the whole world was distracted by the virus, and when everyone was looking the other way—unannounced to the public, in total secrecy on a weekend—passed the most controversial licensing bill, I think, in the history of the FCC," Inhofe added.

Witnesses testifying at the hearing had no explanation when pressed by senators on why the FCC approved the Ligado license modifications, which evolved from a network proposal advanced in 2011 by LightSquared, a predecessor company. LightSquared was reorganized in bankruptcy and renamed Ligado Networks in 2016.

"It's quizzical," said U.S. Coast Guard Adm. (ret.) Thad Allen. The lengthy FCC order "had to be in the works for quite a while, and it happened suddenly," he added. "In my view, that was a breakdown of communications and in building a consensus around proper rulemaking at a regulatory agency."

each chip is not only tuned to GPS but embedded with interconnected electronics each tuned to each other."

A new generation of Military GPS User Equipment (MGUE) consisting of modernized, jam-resistant receiver cards will not be installed across weapons systems until the 2030s, Reed said. "The best course of action for national security," he advised, would be for the FCC to stay the license approval until MGUE chipsets are fitted into critical systems.

Notably unrepresented at the hearing were Reston, Virginia-based Ligado Networks and the FCC. The latter has issued a list of 29 prominent individuals and organizations that support its decision, including U.S. Attorney General William Barr, Secretary of State Mike Pompeo and Sen. Mark Warner (D-Va.).

Barr and others have argued that freeing spectrum to deploy high-speed 5G wireless technology is key to maintaining a competitive edge against China. Conversely, the Pentagon contends that China's BeiDou and Russia's Glonass satellite-positioning systems would benefit from any degradation of GPS.

The office of Rep. Mike Turner (R-Ohio) said May 27 that FCC officials had acknowledged during a conference call with the HASC that they had not sought classified briefings from any of the 13 federal agencies affected by the Ligado order.

"The FCC is the only federal government entity that thinks this is a good idea," stated Turner. "I was concerned when I asked the FCC officials on the call if they had convinced any other agency this was good policy or if they had made an attempt to receive a classified briefing on the effects of their decision, and their answer was 'no'."

LIGADO NETWORKS

The FCC has mandated that Ligado provide a 23-MHz "guard band" and limit its base station power levels to protect against interference with GPS.

Defense Department witnesses testifying at the hearing said they were blindsided by the FCC action.

The FCC announced on April 20—a Monday—that it had approved the license modifications Ligado sought to build a low-power terrestrial network for 5G and internet of things services with conditions designed to prevent interference with GPS. The approval authorizes the company to use three spectrum bands: one that is adjacent to the 1559-1610 MHz band allocated for radionavigation satellite services, including the GPS L1 signal.

The Defense Department estimates that Ligado transmitters potentially could interfere with any of a million legacy GPS receivers embedded in vehicles and weapons systems, costing the Pentagon billions of dollars to replace and delaying training and readiness of its forces.

"Ligado maintains that [the Defense Department] can simply replace affected GPS cards," said Sen. Jack Reed (D-R.I.), ranking member of the SASC. "But there are hundreds of thousands of GPS chips embedded in [Defense Department] weapon systems, and

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Firefly Alpha update p. 60 LauncherOne demo loss p. 62 NASA international Moon policy p. 63

NASA COMMERCIAL EX

> SPACEX'S FIRST HUMAN SPACEFLIGHT

> FOURTH MISSION MAY FLY MOVIE STAR

> ISS SHORT-STAFFED UNTIL SPACE TAXIS CERTIFIED

Irene Klotz Cape Canaveral

THE GRAND EXPERIMENT to replace NASA's decommissioned space shuttle fleet with privately owned and operated space taxi services, a project 10 years in the making, moves into its final phase with the launch of two U.S. astronauts on a shakedown flight to the International Space Station.

Strapped inside a sleek, touchscreen-controlled SpaceX Crew Dragon capsule, veteran NASA astronauts Robert Behnken and Douglas Hurley were scheduled to lift off May 30 and reach the International Space Station (ISS) the following day. An initial launch attempt on May 27 was canceled due to poor weather.

The launch was to be the 85th flight of a Falcon 9 and SpaceX's first with people. "It's super exciting to see this," SpaceX founder, CEO and Chief Engineer Elon Musk tells Aviation Week. "I never thought it would happen."

How long Behnken, 49, and Hurley, 53, will remain onboard the ISS has yet to be determined.

SpaceX's Crew Dragon and Boeing's CST-100 Starliner programs—funded in 2014 for development, testing and operational missions—are so late to the finish line that NASA plans to reassign the test pilots to the ISS crew to help plug staffing shortfalls as paid rides on Russian Soyuz capsules come to an end.

Since the space shuttles were retired in 2011, Soyuz spacecraft have been the sole means of flying crew to and from the ISS, a service that has cost the U.S. more than $4 billion since 2006, according to a NASA Office of Inspector General (OIG) audit in November 2019.

The station currently is staffed by just a single U.S. astronaut and a pair of Russian cosmonauts, half the usual crew size. If all goes well with the Demo-2 mission, Behnken and Hurley will transfer to the ongoing Expedition 63 crew for up to four months. The mission duration will largely be determined by SpaceX's progress preparing the next Crew Dragon spacecraft for flight on the first Post-Certification Mission (PCM), Crew-1, says ISS Program Manager Kirk Shireman.

"We'll be watching the preparation of the Crew-1 vehicle, and when we're confident it's just about ready to go, that's when we'd like to bring home Demo-2," Shireman told reporters before launch. "That way, we can maximize the utility of work aboard the ISS and minimize the amount of time there is a crew of one, while still maintaining the focus on this test flight and making sure we accomplish all the certification requirements that we have."

NASA's 2014 fixed-price, milestone-based Commercial Crew Transportation Capability contracts with SpaceX and Boeing include flight tests and six PCMs apiece. The companies are three years behind schedule due to a range of technical issues with parachutes, launch abort systems and other equipment. Boeing faces an additional nine months of work to recover from the Starliner's troubled uncrewed orbital flight test in December 2019. Software issues prevented the capsule from reaching the ISS.

The ensuing investigation uncovered additional serious software problems, prompting NASA to flag the mission as a "high-visibility close call." Boeing plans to repeat the uncrewed flight test late this year, followed by a crewed flight test similar to SpaceX's Demo-2.

Despite the delays, NASA has been able to keep a fairly tight cap on Commercial Crew Program costs, with SpaceX's contract growing from $2.6 billion to $2.7 billion in six years and Boeing's from $4.2 billion to $4.4 billion. The figures, however, do not include the extra $1 billion NASA has spent to buy additional rides on the Soyuz during the delays, the OIG audit shows.

Overall, NASA awarded more than $8.2 billion in Space Act Agreements and contracts under two Commercial Crew Development phases, the Commercial Crew Integrated Capability initiative, the Certification Products Contract and the Commercial Crew Transportation Capability. Selected companies contributed funding to the programs as well.

NASA estimates the commercial partnering approach cost $20-30 billion less than what it would have spent to develop a low-Earth-orbit transportation system under traditional cost-plus-award-fee contracts, says NASA's Commercial Development director Phil McAlister.

Cutting development cost was not the program's only goal. NASA also wanted a next-generation spaceship that would be far safer than anything previously flown. The agency set a requirement that the Commercial Crew vehicles be designed to limit the risk of loss of life to 1:270 flights and limit the risk of loss of mission to 1:60 flights. The numbers and methodologies for risk assessment were the subject of hot debate, but they were useful for the companies to identify which systems warranted the best use of their time and money to improve, says Patricia Sanders, head of the Aerospace Safety Advisory Panel, which serves as an independent NASA safety watchdog.

"NASA was trying to drive the design changes needed to get the loss-of-crew numbers as low as possible," Sanders tells Aviation Week.

The agency did this by mitigating some of the risk with operational activities such as conducting detailed inspections of the capsules aboard the ISS to check for micromete-

LOGO PHOTO: SHUTTERSTOCK

XPERIMENT TAKES OFF

oroid and orbital debris (MMOD) strikes, which could pose a hazard during reentry. With the inspection, which will be conducted prior to the Crew Dragon's undocking for the return trip to Earth, SpaceX's loss-of-crew number is 1:276, and the overall mission risk is 1:60, NASA says. The single biggest risk is MMOD, followed by the capsule's parachutes.

"It wasn't that easy to get to those numbers," Sanders says. "Both providers had to do some work with the design to get there. And that was the value of those calculations really, to help identify where you can influence it by working your design and operational mitigations when it's appropriate. . . . The number itself is not so important as is understanding what can drive loss of crew and then how you can work to improve your chances."

SpaceX believes its Crew Dragon is so safe that it is planning to fly privately paying passengers on its fourth crewed mission in 2021. "I think that will be the movie mission," SpaceX President and Chief Operating Officer Gwynne Shotwell tells Aviation Week, referring to a project announced on May 5 between actor Tom Cruise and NASA to film aboard the ISS.

"We need popular media to inspire a new generation of engineers and scientists to make NASA's ambitious plans a reality," NASA Administrator Jim Bridenstine wrote on Twitter. "NASA is excited to work with Tom Cruise on a film aboard the space station."

SpaceX has agreements to fly nonprofessional astronauts with Houston-based Axiom Space, which is developing a commercial habitation module to be attached to the ISS, and with Space Adventures, which previously brokered eight tourist flights to the ISS onboard Russian Soyuz capsules between 2001 and 2009. The company also has a deposit from Japanese entrepreneur Yusaku Maezawa for a flight on its next-generation Starship spacecraft around the Moon.

Shotwell expects the Starship to be ready to fly in half the six years of development time it took for the Crew Dragon. "We've learned so much in six years," she says. "It would be a major company fail if we're not flying people in half that amount of time or less."

"I don't think we would have gotten this far without NASA's help," Musk adds. "I'm super grateful for the support of NASA. [Demo-2] is fundamentally a NASA mission that we are supporting here."

SPACEX

A SpaceX Falcon 9 rocket and Crew Dragon capsule poised at the remodeled Kennedy Space Center LC39A ahead of the company's first human spaceflight.

Check 6 *SpaceX CEO Elon Musk and SpaceX President and Chief Operating Officer Gwynne Shotwell talked with Irene Klotz in the runup to the first NASA Commercial Crew launch:* **AviationWeek.com/podcast**

The Sudden (and Untimely) Exit of NASA's Human Spaceflight Chief

> NO IMPACT TO DEMO-2 FLIGHT TEST IS EXPECTED

> LOVERRO ON THE JOB JUST FIVE MONTHS

Irene Klotz Cape Canaveral

One sign of how far NASA is willing to go in its quest to land astronauts on the Moon in 2024—four years earlier than previously planned—came during the agency's announcement of design contracts for human lunar landing systems.

NASA revealed that the lunar-orbiting Gateway, intended to be the building block for an international collaboration to explore and exploit the Moon, was unlikely to be part of the architecture for the first crewed landing.

JOEL KOWSKY/NASA

"The Gateway is important for a sustainable architecture," NASA Administrator Jim Bridenstine told reporters on April 30. "But it also is important to note that we have the priority to get to the Moon by 2024, and we believe that does not require the Gateway. In fact, I would go as far as to say it's not likely that we will use the Gateway for the 2024 mission."

Lead architect for the revamped Moon plan, ordered by the Trump administration in March 2019, has been space policy guru Douglas Loverro, whom Bridenstine recruited last year after sidelining longtime spaceflight chief William Gerstenmaier.

In addition to cutting the Gateway out of the critical path for a 2024 landing, Loverro planned to consolidate the launches of the first two Gateway segments by having them integrated on the ground and launched as combined modules on a single heavy-lift commercial booster.

The plan requires a payload fairing longer than any currently available, but the fairing upsize is among the requirements for companies that are bidding to become one of two U.S. national security space launch providers.

The revised plan, however, retroactively changes the timing and terms under which the Gateway elements were procured.

Additional details of NASA's accelerated blueprint for the Artemis Moon exploration initiative have not yet been released.

Bridenstine hired Loverro specifically because of his 40 years of experience crafting space policy, managing technical programs and introducing novel contracting mechanisms for the Defense Department and the National Reconnaissance Office. Those skills seemed to be a good fit after Vice President Mike Pence told Bridenstine to accomplish the 2024 Moon landing "by any means necessary."

But Loverro's maverick ways proved too much for NASA. On May 18, Loverro was asked to resign, and he complied, effective immediately. He had been on the job just five months.

NASA has declined to comment on the reason or the timing of Loverro's departure, which came three days before he was to chair the Flight Readiness Review for the agency's first launch of astronauts from the U.S. since the end of the shuttle program in 2011. Launch of the SpaceX Demo-2 flight test was targeted for May 30 following a scrub on May 27 due to weather.

"I am deeply concerned over this sudden resignation, especially eight days before the first scheduled launch of U.S. astronauts on U.S. soil in almost a decade," U.S. Rep. Kendra Horn (D-Okla.) said in a statement. "Under this administration, we've seen a pattern of abrupt departures that have disrupted our efforts at human spaceflight."

Doug Loverro was asked to resign as associate administrator for human exploration and operations after five months on the job.

In a farewell letter to employees, Loverro noted that leaders are sometimes called on to take technical, political or personal risks, all of which "have potential consequences if we judge them incorrectly.

"I took such a risk earlier in the year because I judged it necessary to fulfill our mission. Now, over the balance of time, it is clear that I made a mistake in that choice for which I alone must bear the consequences," Loverro wrote.

Loverro declined to elaborate but told Aviation Week that if he were going to do everything all over again, he would not do anything differently. "I have no regrets," Loverro says.

He also said his resignation is unrelated to an ongoing NASA Office of Inspector General (OIG) audit of the Artemis exploration strategy. "That OIG report that is auditing Artemis strategy has barely just begun, so there was no connection with that particular OIG audit and anything to do with me," Loverro says.

With Loverro's departure, Bridenstine tapped former astronaut Kenneth Bowersox to serve as acting associate administrator for human exploration and operations, his second time at the job. Bowersox filled in following Gerstenmaier's sudden reassignment in July 2019 and served until Loverro joined NASA in December.

FAST 5

Fast Five With Elon Musk

As two NASA astronauts prepared to launch on the flight test of SpaceX's Crew Dragon transportation system—the company's first human spaceflight—SpaceX founder, CEO and chief engineer **Elon Musk** spoke with *Aviation Week & Space Technology* Space Editor **Irene Klotz** on May 23 about new beginnings and lessons learned.

SPACEX

Demo-2 will be SpaceX's 85th Falcon 9 launch. What's the vibe like to have people aboard for the first time? The stakes are much higher, of course. You can always rebuild a satellite. With loss of life, there's no rebuilding that. We've gone to extreme lengths to review safety standards—the design of the rocket, the manufacture of the rocket. We've turned over every stone so many times I've lost count. NASA has been an integral part of those reviews. We've had multiple outside agencies, like the Aerospace Safety Advisory Panel and others, also review things, so the level of scrutiny is much higher than for satellite missions.

What do you think is the riskiest part of the system? The part that I would worry most about would be reentry, which won't happen, hopefully, for a few months from now. With Dragon 1, we have a simple conic on the leeward side—essentially the back shell—of the spacecraft, so it's really quite symmetrical, with no particular protuberances or anything. Whereas with Crew Dragon, because we have the escape thrusters side-mounted into the back shell, that creates an asymmetry. If you rotate too much, then you could potentially catch the plasma in the SuperDraco escape-thruster pods and could cause control disturbance or overheat things. We've looked at this six ways to Sunday, so it's not that I think this will fail. It's just that I worry a bit that it is asymmetric on the back shell and you could have a strange sort of roll coupling as you come in if you turn too much. I think this is low-risk, but that's what I would put as my biggest concern.

It's been 18 years for SpaceX to get to this point. If you were doing this all over again, would you do anything differently to make this path shorter? Hindsight is always 20-20. There are a lot of design decisions I think I would have made differently. The architecture that Dragon uses—blunt-body reentry with hypergolic propellants and side-mounted thrusters—made sense at the time, but we just did not have any clue of what a system looks like that is able to create a base on the Moon and a city on Mars.

Starship is kind of that thing, so I guess if I could go back in time, I would probably not use hypergolic propellants, because they're very expensive and difficult to handle, and I wouldn't use a blunt-body reentry vehicle. These are all design decisions that work fairly well for Earth orbit but are not well-suited for going back and forth to the Moon or for going to Mars.

Do you think having NASA as a development partner speeded things up or slowed down the process? I suppose both. I don't think we would have gotten this far without NASA's help. On the other side, once the system is working, there is a tendency at NASA to want to keep using that same system. We're going to push for the next-generation system, which NASA is also supporting, with the Starship to the Moon. I'm super grateful for the support of NASA. We definitely would not be where we are without that.

This is fundamentally a NASA mission that we are supporting here.

Are you thinking about taking a ride on Crew Dragon? Probably not, because I need to focus on advancing Starship. The goal of SpaceX has always been to create the technologies to extend life beyond Earth, to make us a spacefaring civilization and a multiplanet species. I certainly would enjoy going to orbit, but it would take up a lot of time, and then I would not be able to work on Starship. And I have Tesla obligations as well. I certainly would like to go, at some point, to the Moon or Mars."

A GIANT

SpaceX CEO Elon Musk, left, and NASA astronauts Doug Hurley, center, and Bob Behnken talked on March 1, 2019, before the Demo-1 mission.

NASA

Irene Klotz Cape Canaveral

SHUTTERSTOCK PHOTO IN LOGO

THE STORY OF SPACEX'S path to human spaceflight begins, of course, with Elon Musk, who is now deep in the design and testing of a spaceship to colonize Mars.

That project may sound audacious, but 12 years ago, watching Musk's Falcon 1 rockets blow up over Omelek Island in the Marshall Islands' Kwajalein Atoll, it would have seemed similarly far-fetched that two veteran NASA astronauts would be blasting off aboard a SpaceX Falcon 9 rocket in a week to test its new Crew Dragon capsule.

Musk founded SpaceX in 2002 with the goal of making humanity an interplanetary species. The first step was to design a safe, reliable rocket that was easier and less expen-

SpaceX Steps to Human Spaceflight

Technology entrepreneur Elon Musk started SpaceX with the goal of building an inexpensive, reliable rocket to launch satellites—and then people—to orbit with the ultimate goal of colonizing Mars. After 18 years, SpaceX is on the verge of turning the Falcon 9 rocket Dragon capsule into a crewed transportation system. Here is a look at the company's milestones along the way.

March 2002
Elon Musk, 30, founds Space Exploration Technologies, nicknamed SpaceX, and begins developing the Falcon 1 rocket, with the goal of launching small payloads for $6 million per flight. DARPA buys the first two missions.

STANFORD UNIVERSITY

August 2006
SpaceX wins a NASA Space Act Agreement to develop a cargo resupply line to the International Space Station (ISS). The Commercial Orbital Transportation Services (COTS) contract, ultimately worth $396 million, is followed two years later by a $1.6 billion Commercial Resupply Services (CRS-1) contract for ISS cargo flight services.

NASA

September 2008 After three successive failures, Falcon 1 reaches orbit on Sept. 29, 2008, delivering a test payload called Ratsat into an orbit at an altitude of 386-400 mi. Musk said that if the launch had failed, SpaceX, which was nearly out of money, would have shut down.

SPACEX

July 2009 Falcon 1 makes a fifth and final flight from Omelek Island, part of the Marshall Islands' Kwajalein Atoll, putting Malaysia's RazakSAT into orbit to complete SpaceX's first successful commercial

LEAP FOR SPACEX

> DEMO-2 TO PAVE WAY FOR COMMERCIAL SERVICE

> THE COMPANY'S LONG-TERM GOAL IS MARS

sive to manufacture and operate than currently available systems. Musk and a team of about 30 employees set about developing the Falcon 1, a 68-ft.-tall, two-stage, liquid-oxygen and RP-1 kerosene-fueled booster.

About that time, NASA, facing the end of the space shuttle program, was casting about for options to fly cargo and eventually crew to the International Space Station (ISS). The agency set up a Commercial Orbital Transportation Services (COTS) demonstration competition and received 21 proposals from 20 companies. SpaceX, which had yet to launch a single rocket, was one of six companies awarded Space Act Agreements in August 2006 to develop and demonstrate COTS.

NASA's initial $278 million investment in SpaceX has helped create a company that now employs more than 7,500 people and is worth in excess of $30 billion. From COTS, SpaceX went on to win one of two Commercial Resupply Services (CRS) contracts to fly cargo to and from the ISS. When NASA awarded the CRS contracts in December 2008, SpaceX's flight record stood at three Falcon 1 failures and one success.

SpaceX then won development contracts for NASA's companion Commercial Crew Program, launch service contracts to fly NASA science satellites and a flight service contract to ferry astronauts to and from the ISS. NASA hopes to start crew ferry flights in October.

In April 2020, NASA made another commitment to spend $135 million over the next 10 months to help assess whether SpaceX technology in development for the Mars-class transport spacecraft, called Starship, can be quickly repurposed to help NASA fulfill a plan from the administration of President Donald Trump to land a pair of astronauts on the south pole of the Moon in 2024.

With the Human Landing Systems award, NASA's business with SpaceX has grown to $8.4 billion through 2024, with $7.7 billion allotted to cargo and crew transportation, an April 2018 audit by NASA's Office of Inspector General shows. An additional $614 million has been awarded to SpaceX for launches of seven NASA science satellites.

SpaceX has also broken into the national security space market, winning contracts worth a combined $767 million since its first U.S. Air Force launch contract in March 2017.

After reaching orbit twice, Falcon 1 was retired in 2009. SpaceX is now in its fifth and final version of the Falcon 9, which has flown 84 times, with one failure and one launch-pad accident ahead of flight.

Now 18 years in the making, Musk's dream to fly people in space is about to take wing, with U.S. Air Force Col. Robert Behnken and U.S. Marine Col. Douglas Hurley scheduled to launch aboard a SpaceX Crew Dragon capsule on May 30. An initial attempt on May 27 was scrubbed due to weather.

"The folks at SpaceX as well as the Commercial Crew Team [at NASA] have just spent a ton of time working on this vehicle and honing it to the vehicle that is right now," Hurley says. "It's been through all kinds of different testing, culminating a few months ago with the inflight abort, which is probably one of the most incredible things I've ever seen in person. It's an outstanding flying machine."

For Musk, the leap into human orbital flight has taken far longer than expected. "If we're going to have a base on the Moon and get people to Mars," he tells Aviation Week, "we better improve our progress—a lot—for it to happen before we're dead."

mission. Plans for an upgraded Falcon 1 are shelved, and SpaceX shifts its focus to developing the Falcon 9 and a launch complex at Cape Canaveral AFS.

SPACEX

June 2010 Falcon 9 debuts with the launch of a Dragon qualification spacecraft on June 10, 2010.

December 2010 On its second Falcon 9 mission, SpaceX launches a Dragon spacecraft test capsule.

May 2012 NASA agrees to combine the objectives of COTS Demo Flights 2 and 3 into a single mission, and Dragon becomes the first commercial spacecraft to reach the ISS. SpaceX begins working on its CRS-1 contract in October.

NASA

December 2013 Falcon 9 makes its first flight to geostationary transfer orbit with the launch of the SES-8 communications satellite.

SPACEX

May 2014 SpaceX unveils the design for its Crew Dragon spacecraft and says the price to fly will be approximately $20 million per seat. At the time, rides on a Russian Soyuz capsule cost NASA $76 million.

September 2014 NASA selects SpaceX and Boeing to develop commercial space taxis under its Commercial Crew Program.

DIMITRI GERONDIDAKIS/NASA

May 2015 SpaceX conducts a Crew Dragon pad abort test, proving the capsule's emergency escape system.

June 2015 After a string of 18 successful Falcon 9 flights, a 19th launch on June 28, during the CRS-7 mission for NASA, ends 2.5 min. after liftoff due to overpressuriza-


NASA

tion of the second-stage liquid oxygen tank. The Dragon cargo ship survives the explosion but is not configured to deploy parachutes and is lost at splashdown. The Falcon fleet is grounded for six months.

November 2015 SpaceX demonstrates Crew Dragon SuperDraco propulsive descent capabilities during a tethered flight test at the company's rocket development facility in McGregor, Texas.

December 2015 SpaceX recovers from the CRS-7 accident and not only launches 11 satellites for Orbcomm but also successfully lands the Falcon 9 first stage for the first time. The rocket touches down on a landing pad at Cape Canaveral AFS. It is put on permanent display outside SpaceX headquarters in Hawthorne, California.


US-LAUNCHREPORT.COM

September 2016 SpaceX loses a Falcon 9 rocket and Spacecom's Amos-6 satellite in a launchpad explosion at Cape Canaveral AFS prior to a routine static test fire. The accident is traced to a failed composite overwrapped pressure vessel (COPV), which is used to store helium to pressurize propellant tanks. NASA and the Air Force, which started buying SpaceX launch services in April 2016, call for the COPVs to be redesigned.

February 2017 NASA's Kennedy Space Center Launch Complex 39A is back in business as a launchpad for SpaceX Falcon rockets. The pad, used to launch Saturn V rockets and the space shuttles, was later modified and updated by SpaceX for the Commercial Crew program.


NASA

March 2017 SpaceX refurbishes and reflies a Falcon 9 booster for the first time, sending the SES-10 communications satellite into orbit. The booster, which previously was used for the CRS-8 mission in April 2016, makes a successful second landing, this time on a drone ship in the Atlantic Ocean.


SPACEX

June 2017 NASA agrees for the first time to use a previously flown Dragon spacecraft.

Boeing Regroups and Cheers SpaceX On

> SECOND UNCREWED FLIGHT TEST IS ON TAP

> CREW FERRY FLIGHTS PLANNED TO START IN 2021

Irene Klotz Cape Canaveral

On the wall in Elon Musk's office is a framed *Aviation Week & Space Technology* cover from March 2004 that reads "David and Goliath: Can Tiny SpaceX Rock Boeing?" (*AW&ST* March 29, 2004).

"It's kind of a comical photo, to be frank, because I think the implied answer is 'no,'" Musk tells Aviation Week.

No one is laughing now, least of all Boeing, which won a NASA Commercial Crew Transportation Capability contract for development, test and flight services along with SpaceX in September 2014.

At the time, Musk's SpaceX, founded in 2002, had launched five Falcon 1 rockets—the first three of which failed—and a dozen Falcon 9s. Boeing was two years shy of its centennial anniversary and had been involved with every U.S. human spacecraft since the 1960s Mercury program.

Although money was tight, NASA was determined to fund both companies' development efforts, believing the competition would spark innovation, ratchet up attention to safety and help control costs. In the process, the International Space Station (ISS) would get some much-needed backup for the Russian Soyuz spacecraft that had been solely responsible for crew ferry flights since the U.S. retired the space shuttle fleet in 2011.

Developing two space taxis not only would break reliance on Russia and shift payment for crew flight services back to U.S. companies, but it would potentially spark a new U.S. industry for commercial human spaceflight.

Both SpaceX and Boeing faced unexpected technical hurdles with their capsules' parachutes, launch abort engines and other systems. SpaceX also had to recover from two Falcon 9 rocket failures—first in 2015 during a cargo run to the ISS and the second a year later during propellant loading for a routine prelaunch static fire test.

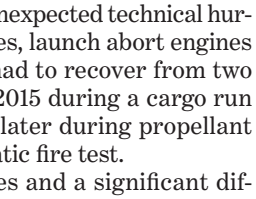
Despite vastly different cultures and a significant difference in NASA funding—SpaceX's 2014 award was for $2.6 billion, 38% less than Boeing's $4.2 billion—until recently the companies were neck and neck in a low-key race to be the first to fly crew to the ISS.

That ended in December when software problems prevented Boeing's uncrewed CST-100 from reaching the ISS for a trial run. In the aftermath, other problems were uncovered, forcing Boeing to review 1 million lines of code and schedule a second uncrewed Starliner flight test for later this year.

And so it is Musk's SpaceX that is poised to fly first, sending NASA astronauts Robert Behnken and Douglas Hurley into orbit for what will be the company's first human spaceflight and the first U.S. crewed launch since 2011.

"I'm just happy that someone is getting ready to fly," says Boeing astronaut Chris Ferguson, whose flight test aboard the Starliner with NASA astronauts Michael Fincke and Nicole Aunapu Mann is now not expected to occur until 2021. "Both companies have waited a long time for this" he adds.

"This dream that was conceived almost a decade ago is finally coming to the point where we really are going to fly commercial passengers, and we're going to service the International Space Station," says Ferguson, a former NASA astronaut who commanded the final space shuttle mission. "It's literally on our doorstep, so it's not important who wins. It's important that we get there, and I will be at [Kennedy Space Center] to watch Bob and Doug launch."


FRANK MICHAUX/NASA

Boeing's CST-100 Starliner, pictured after an abbreviated uncrewed flight test in December, is expected to fly again—with crew—next year.

February 2018 SpaceX debuts its long-awaited triple-core Falcon Heavy rocket. As a test payload, SpaceX launches a Tesla roadster owned by Musk into a solar orbit that stretches as far away as the company's ultimate goal—Mars.


SPACEX

May 2018 SpaceX debuts its fifth and final version of the Falcon 9 booster, featuring higher engine thrust, improved landing legs and dozens of changes to streamline recovery and reusability. The booster is certified for national security space missions and will be used to fly NASA astronauts and, eventually, paying passengers.

March 2019 An uncrewed Crew Dragon capsule docks with the ISS on March 3, becoming the first U.S. spacecraft to autonomously dock at the orbital laboratory. It returns to Earth five days later.


NASA

April 2019 The Crew Dragon Demo-1 capsule is destroyed during preparations for a static firing at Cape Canaveral AFS, delaying an upcoming inflight-abort test.

January 2020 SpaceX conducts its final major uncrewed flight test, demonstrating Crew Dragon's high-altitude abort capabilities.


SPACEX

April 2020 SpaceX completes its 20-flight CRS-1 contract and retires the first version of its Cargo Dragon capsule. Under a follow-on CRS-2 agreement, SpaceX will use a modified version of its Crew Dragon capsules, also known as Dragon 2, for cargo missions beginning in late 2020.

May 2020 The first Crew Dragon capsule that will fly with astronauts aboard arrives at Kennedy Space Center LC39A ahead of a planned May 30 liftoff.


KIM SHIFLETT/NASA

Final Countdown

- INTEGRATED STAGES 1 AND 2 DUE AT VANDENBERG AFB BY AUGUST
- FIRST FLIGHT TARGETS DIRECT INJECT TO 300-KM-HIGH ORBIT FOLLOWED BY EXPERIMENTAL RELIGHT

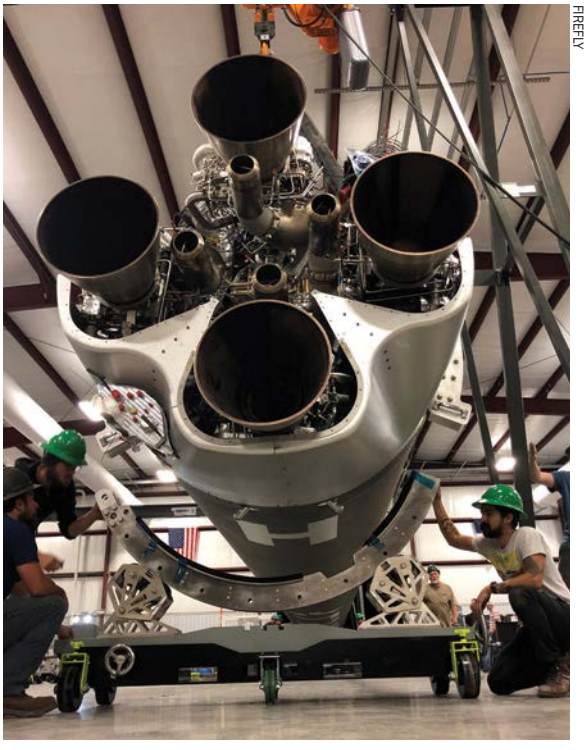
Guy Norris Los Angeles

Assuming an ongoing series of critical tests go according to plan over the next four months, a new U.S.-built rocket will arc into space from California sometime this fall, forging a low-cost route to orbit and increasing orbital access for small- and medium-satellite providers.

That is the hope of Tom Markusic, CEO of startup Firefly Aerospace, which aims to complete the first launch of the two-stage Alpha rocket from Vandenberg AFB as early as September. The road to liftoff has not been easy, or fast, but with final first-stage engine hot-fire tests underway through May and infrastructure building up at the Pacific coast launch site, Markusic says that "so far, everything looks to be on track."

The company's 97.6-ft.-tall Alpha launch vehicle is designed to break the cost barrier for lofting payloads as large as 1,000 kg (2,200 lb.) to a 200-km (120-mi.) low Earth orbit (LEO), or as much as 630 kg to a 500-km sun-synchronous orbit (SSO). With a starting price of $15 million, Firefly is targeting the lowest cost per kilogram to orbit in its vehicle class and, based on hopes for two successful flights by year-end, is aiming for an eventual launch cadence of two flights per month.

On top of fast-track launch capability, Firefly is basing its low-cost equation on several key building blocks, including a lightweight vehicle structure, a high-performance propulsion system and more affordable avionics. As the initial production engines and carbon fiber composite structure, including nonmetallic cryogenic propellant tanks, come together at the company's Briggs, Texas, test site, Markusic says the indications are positive for meeting, and potentially exceeding, initial design goals.



FIREFLY

Four Reaver Stage 1 engines will boost Firefly's Alpha launch vehicle with a combined thrust of more than 165,000 lb.

"One thing that's been pretty extraordinary about the development of this vehicle is it has come in on [specification in terms of] design mass and performance," he says. "With respect to the rocket engine, that's come in right out of the gate. Usually in development programs, mass grows, and there are performance deficiencies. But it's really a tribute to the team that we are right on design. So we expect to have full capacity very soon after the first flight. We actually see a lot of potential to add at least 20% more payload capacity to Alpha in short order."

The company's optimism partially is based on the benefits of the composite structure, which it says is up to 30% lighter than a comparable metallic rocket body with similar performance.

The Alpha's Reaver first-stage engine, a scaled-up derivative of the Lightning upper-stage engine, is "one of the most outstanding technical things we've done with Firefly," says Markusic, who describes the design as "the world's simplest pump-fed rocket engine." The Reaver traces its origins to the single combustor Firefly Rocket Engine (FRE-1) upper-stage engine originally developed by Firefly Space Systems, the predecessor of today's company. Firefly Space Systems shut down in 2016 after a key investor withdrew, but the current company, newly backed by Noosphere Ventures, was relaunched as Firefly Aerospace in 2017.

The Reaver, which replaces the clustered FRE-2 aerospike configuration proposed in the initial Alpha concept, has demonstrated 95% combustion efficiency in tests, he adds. The design utilizes liquid oxygen/kerosene (LOX/RP-1) fuel and a combustion tap-off power cycle in which some of the exhaust energy from the main combustion chamber is diverted to power the engine's single-shaft turbopumps.

"Although others have worked on the tap-off cycle, no one has ever built an orbital boost engine or even one that uses RP-1 propellant. We're the first ones to do that," says Markusic, making an oblique reference to other space programs such as Blue Origin's BE-3 liquid hydrogen/LOX engine developed for the company's New Shepard suborbital launch vehicle.

Firefly says a key benefit of the tap-off cycle, which is also a form of open-cycle gas-generator (GG) propulsion system, is greater simplicity. Previous open-cycle engines such as the Saturn's F1 and current RP-1-fueled systems such as SpaceX's Merlin are configured with two combustion devices: one for thrust and the other for powering the LOX/RP-1 turbomachinery. The Alpha's engines are configured with only a single combustor for both functions. Although tap-off has also been

demonstrated on hydrogen-fueled engines, Markusic says Firefly is the first to apply the technique successfully to an RP-1-fueled design.

The Alpha's engine design also gets around a perceived disadvantage of the tap-off cycle, which normally sacrifices some propellant to cool the combustion chamber gases driving the turbomachinery. "We found a way to do this without wasting any fuel for cooling, which was pretty extraordinary and ultimately makes the engine very efficient," says Markusic, who declines to provide details of how this is accomplished. "That's our proprietary, patent-pending secret sauce that we really can't share at this stage of development," he adds.

Explaining the transition away from the once much-vaunted aerospike concept in the original design to today's pump-fed Lightning/Reaver engine configuration, Markusic says: "[This was made] because we were able to develop turbomachinery very quickly in house. It made going to a conventional rocket engine more favorable for the vehicle as opposed to the pressure-fed engines that we were going to use on the first version. Moving away from pressure-fed meant that the benefits of the aerospike were no longer as important."

Some aspects from the first phase, however, have carried over to the current design, including the know-how to develop smaller-scale, regeneratively cooled, nickel-plated-copper-alloy thrust chambers. Although the same basic design had been used in the early 1970s for the development of the Aerojet Rocketdyne RS-25 space shuttle main engines. "We had to learn how to do that from scratch," Markusic says. "So the aerospace combustors were designed and built using the same type of fabrication methodology and analytical tools. All of that went into the building of Lightning and Reaver."

The four Reaver engines for the Flight 1 Alpha launch vehicle are undergoing acceptance tests at Briggs throughout May before being installed in the 61.6-ft.-tall first-stage section for integrated tests in June. The LOX first-stage tank, which Firefly says is the largest all-composite tank of its type ever made, passed its acceptance test on May 12.

The second-stage Lightning engine is meanwhile set for acceptance tests in June with integrated upper-stage testing due the following month. The completed first stage is expected to ship to Vandenberg AFB in July, and the 18.6-ft.-tall second stage is due to follow in August. The wet dress rehearsal for the stacked vehicle, including the 16.9-ft.-payload section, is scheduled for September, followed by the first flight attempt later the same month.

FIREFLY PHOTOS

The integrated second stage, pictured in earlier testing, is due to undergo final acceptance tests in July.

The first-stage LOX tank, the largest composite structure of its kind, passed acceptance tests in mid-May.

Preparations at Firefly's Space Launch Complex 2 West (SLC-2W) launch site also continue, as transportation of key structures and assemblies are getting underway from Texas to California. Among the first elements were the mobile launch stand, a part that stabilizes the rocket on the pad, which was delivered to Vandenberg in May. A combined transporter-erector will follow next, with the first parts due to arrive in California in June. Final assembly of the unit is expected to take place in July.

The initial mission, Alpha Flight 1, will wring out the vehicle's overall performance—including an experimental second-stage relight—as well as structural, systems and avionics responses; vehicle-to-ground system communications; and exoatmospheric thermal environments. Carrying a payload of cubesats, small satellites and a dragsail to assist in deorbiting the upper stage, the first launch will attempt a direct-inject orbital insertion to an altitude of 300 km with a 130-deg. inclination and a 140-deg. launch azimuth. The plan to directly inject into orbit with a single rocket engine burn is considered less risky and, following payload separation, will allow for an experimental upper-stage relight.

In addition to the dragsail, an 18-m^2 (194-$ft.^2$) deployable device developed as the Spinnaker 3 satellite by Purdue University, other Flight 1 payloads include the NPS-Cenetix-Orbital 1 communications experiment developed by the U.S. Naval Postgraduate School for tests with the U.S. Marine Corps. A series of educational and institutional payloads will also be deployed for various organizations, companies and universities, including the Teachers in Space Project, Hawaii Science and Technology Museum, Benchmark Space Systems, the University of Southern California, Fossa Systems, the University of Cambridge and Firefly itself.

Although the company's initial focus has been on polar and SSO launches from Vandenberg AFB, plans are also underway to develop launch capability to inclinations ranging from 29 deg. to 57 deg. from Cape Canaveral AFS. The East Coast site, located at the Cape's SLC-20 pad, will be activated around a year after work at Vandenberg is completed.

Virgin Orbit Closes In On Cause of LauncherOne Demo Loss

> NewtonThree engine shuts down prematurely after 4-sec. run

> Overall mission proved the principles of air-launched ops

Guy Norris Los Angeles

Everything with Virgin Orbit's first LauncherOne orbital test launch on May 25 was going according to plan until, just seconds into its flight, the first-stage engine unexpectedly shut down, dooming the rocket to an ignominious plunge into the Pacific Ocean.

Yet despite the rocket's loss, the space company says these few seconds of powered flight, plus the precisely executed hours of buildup to the vehicle's release, fundamentally "proved out via flight the foundational principles of our air-launched operations." Just as vitally for its space launch plans, Virgin Orbit says the wealth of test data obtained gives it confidence that the cause of the malfunction will soon be understood.

The rocket test, which marked the first bid to air-launch a liquid-fueled orbital launch vehicle, began when the two-stage LauncherOne was dropped from the company's Boeing 747 carrier aircraft at an altitude of 35,000 ft., west of the Californian coastal island of San Nicolas. The 747, flown to the launch zone from Virgin Orbit's Mojave Air and Space Port base by chief test pilot Kelly Latimer and co-pilot Todd Ericson, dropped the 57,000-lb. rocket while executing a special zoom climb pitch-up maneuver.

Following the release, the 747 banked steeply away, and 5 sec. later the rocket's NewtonThree first-stage liquid oxygen/RP-1 engine ignited automatically. Virgin notes that "on our first ever attempt, we achieved in-air ignition and steady state operation of our main stage rocket engine," and the company adds that once the engine was running, guidance and control systems steered LauncherOne along its predicted trajectory.

However, the engine ran for just over 4 sec. before abruptly shutting down. Virgin Orbit says that "about 9 sec. after drop, something malfunctioned, causing the booster-stage engine to extinguish, which in turn ended the mission." The vehicle stayed within the predicted downrange corridor and fell into the ocean. For this mission the NewtonThree was expected to burn for just under 3 min., accelerating LauncherOne to around 8,000 mph. Following main-engine cutoff and stage separation, the smaller NewtonFour upper stage was then due to continue accelerating a special test payload into a polar orbit at around 17,500 mph.

LauncherOne's rocket engine burned briefly as the Boeing 747 carrier aircraft, Cosmic Girl, banked sharply away following vehicle release.

VIRGIN ORBIT

Virgin Orbit says the short-lived flight successfully demonstrated "all of our prelaunch procedures, captive carry flight out to the drop site, clean telemetry lock from multiple dishes, a smooth pass through the racetrack, terminal count, and a clean release from the aircraft." The manufacturer adds that the event "marked our first flight with cryogenic liquid oxygen loaded into the rocket—and only our second-ever flight with cryogenic materials on board." The flight also proved that the rocket's linerless composite tanks could withstand stresses associated with the flight loads under the 747's wing as well as the release maneuver while carrying a full load of cryogenic oxidizer.

"Test flights are instrumented to yield data, and we now have a treasure trove of that," says Virgin Orbit CEO Dan Hart, describing the mission loss. "We accomplished many of the goals we set for ourselves, though not as many as we would have liked. Nevertheless, we took a big step forward. Our engineers are already poring through the data. Our next rocket is waiting. We will learn, adjust, and begin preparing for our next test, which is coming up soon."

For the follow-on attempt, a second LauncherOne is close to completion at Virgin Orbit's Long Beach, California, facility, where the vehicle has been moved to the final integration area of the factory ready for system-level testing. "If hardware changes are needed, we'll be able to make them quickly, thanks to our vertically integrated, state-of-the-art rocket factory," adds the company. "And if we decide we want to run a few experiments, we've got a factory full of flight hardware we can use for whatever tests we need."

Prior to the flight, which took place eight years after Virgin publicly revealed ambitions to develop an air-launched small-satellite rocket, Will Pomerantz, Virgin Orbit's vice president of special projects, set expectations for the mission. "History is not terribly kind to maiden flights," he said. "Taking my best faith estimate, about half of maiden flights fail. So that's sort of the historical odds we're up against."

Following the LauncherOne failure, private spaceflight pioneers Elon Musk, founder and CEO of SpaceX, and Rocket Lab CEO Peter Beck were among those who sent messages of sympathy and encouragement. Commenting on Twitter, Musk wrote: "Orbit is hard. Took us four attempts with Falcon 1." Three Falcon 1s were lost in launch attempts in 2006-08 before the fourth vehicle was successfully launched into orbit in September 2008.

NASA Lays Out Policy Blueprint for International Moon Exploration

> POLICY ESTABLISHES KEEP-OUT ZONES FOR MINING OPERATIONS

> AGENCY REAFFIRMS USE OF SPACE FOR PEACEFUL PURPOSES

Irene Klotz Cape Canaveral

Countries interested in joining the U.S. Artemis Moon program will be asked to contribute more than hardware: NASA wants potential partners to commit to upholding protocols for deep-space exploration and development, including the extraction and use of indigenous resources such as lunar water ice.

Using the 1967 United Nations Outer Space Treaty as a blueprint, NASA has developed a framework for conducting missions on and around the Moon, which it hopes to parlay into a series of bilateral agreements with other countries.

Operators of private lunar excursions also would be asked to sign the Artemis Accords, named for NASA's current deep-space exploration initiative, which includes a landing on the south pole of the Moon by a male and a female U.S. astronaut in 2024.

The Artemis Accords build on the intergovernmental agreement that legally underpins the International Space Station program and ongoing work to develop international pacts for the planned lunar-orbiting Gateway, a small outpost intended as a staging ground for human and robotic lunar-surface sorties. The Gateway also would serve as a technology testbed for eventual human exploration of Mars.

"As we move forward with the Artemis program . . . we need a new legal framework that can keep up with this ambitious activity. That's what the Artemis Accords are meant to be," Michael Gold, NASA's acting associate administrator for international and interagency relations, tells Aviation Week.

The Accords build on already established agreements for space operations, such as spacecraft registration requirements and emergency astronaut rescue services, and broadens the range of activities to include the extraction and use of resources mined from the Moon, asteroids and Mars.

The agreement, unveiled on May 15, also expands the use of international operability standards (*AW&ST* Nov. 12-25, 2018, p. 30), calls for the public release of science data, and protects heritage sites and artifacts on the Moon.

"With numerous countries and private-sector players conducting missions and operations in cislunar space, it's critical to establish a common set of principles to govern the civil exploration and use of outer space," NASA wrote in a summary of the Artemis Accords presented to the NASA Advisory Council's Regulatory and Policy Committee on May 15.

With backing from the National Space Council, the State Department and other U.S. agencies, NASA now intends to move forward to secure agreements with other countries that would bind them to the Artemis Accords. First and foremost, partners must affirm that their activities in space will be for peaceful purposes, Gold notes.

"That's at the very heart of the Outer Space Treaty and, of course, is a vital principle for any civil space program," he says.

NASA is opening discussions with partners in the Artemis Moon exploration program to sign a policy agreement.

NASA

Signatories must agree to be open about their activities. "NASA has always been very transparent, domestically and internationally, relative to our activities—where we're going, what we're doing—and we would like partners on the Artemis program to follow suit and continue to do so," Gold says.

The agreement also addresses the extraction and use of resources on the Moon and other bodies by establishing keep-out zones and safety buffers to prevent harmful interference by other operators.

"We hope there is nothing in the Artemis Accords that any responsible, spacefaring nation would disagree with," Gold says. "Even if a country doesn't sign the Artemis Accords, it's important for the U.S. to lead, not only in technology but also in policy. As an attorney, I, of course, appreciate the importance of precedent, and that's what the Artemis Accords will do."

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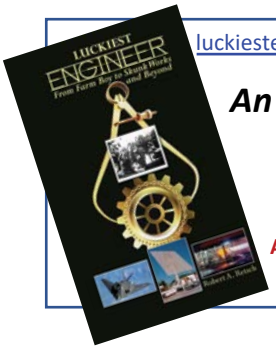

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Aerospace Calendar

To submit Aerospace Calendar Listings
email: aero.calendar@aviationweek.com

June 2-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

Aviation Week Network Events

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

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

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

Sept. 23-24—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.

Oct. 26-27—CAPA Airline Leader Summit: Making Money 2020. Dublin.

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Who Will Pay the Piper?

By **John Dowdy**

The rapid onset of the novel coronavirus has wreaked havoc on markets around the world, hitting commercial aviation especially hard as load factors plummet, flights are canceled and suppliers cut production rates and furlough workers. Amid all this disruption, defense manufacturers appear to have been relatively unscathed. But defense has always been a long-cycle business, driven more by annual budgets than daily load factors. And as the bill for rebuilding the global economy mounts, defense budgets are sure to come under pressure.

COVID-19 is first and foremost a human tragedy, and its continued spread is still a major concern. But we must solve for both the virus and the economy; the dual imperative of our time is the desire to preserve lives and livelihoods. Both will require substantial resources for public health and for economic rejuvenation. Countries around the world are making massive investments to rebuild battered economies, putting out more than $11 trillion in the last 2.5 months, with more sure to follow.

In the U.S., Congress passed the $2.2 trillion Coronavirus Aid, Relief, and Economic Security (CARES) Act at the end of March, bringing the total stimulus thus far to $3 trillion, which could push the fiscal 2020 budget deficit to a record $3.8 trillion, an eye-watering 18.7% of the country's GDP. Other countries have passed similar aid packages, leading to soaring debt levels around the world. And more may well be necessary: The House has passed proposals for another $3 trillion in aid, although the bill's fate in the Senate is unclear.

Government debt levels are already high, swelling as the global financial crisis of 2008 caused a drop in tax revenues and a rise in social-safety-net payments. And the wave of deleveraging many expected as the recession eased never materialized: From 2008 to mid-2017, global government debt more than doubled, reaching $60 trillion. According to the International Monetary Fund (IMF), this year's increase in public-sector debt has reached 122.4% of gross domestic product (GDP) on average in developed countries.

Increased deficits worldwide are likely to put pressure on all discretionary spend, including defense. In the U.S., military spending accounts for 15% of all federal and roughly half of discretionary spending, so defense may come under real pressure. Rep. Ken Calvert of California, the ranking Republican on the House Appropriations defense subcommittee, says defense budgets were strained even before this year's unplanned burst of deficit spending. "There's no question that budgetary pressure will only increase now for all segments of our federal budget, including defense," Calvert said. Defense Secretary Mark Esper has said he is preparing for future defense budget cuts and that legacy systems may need to be scrapped to pay for more modern forces.

South Korea shows early signs of this trend, with leaders recently announcing a shift in resources to disaster relief in response to the pandemic. Money came from education, agriculture, and environmental protection but mostly from defense. This example is particularly significant, given that South Korea is still technically at war, frozen in conflict with its immediate neighbor to the north. Furthermore, South Korea has been more effective than its peers in addressing the pandemic with a swift medical response and widespread testing that allowed the country to reopen its economy faster than other advanced countries. If South Korea is altering its budgetary priorities, others could follow.

LOCKHEED MARTIN

"GOVERNMENTS MAY SET DEFENSE BUDGETS IN LINE WITH THEIR DIMINISHED RESOURCES."

The coronavirus has already had a massive human cost, resulting in approximately 300,000 deaths, including more than 90,000 Americans, more than were killed in Vietnam, the Gulf War, Iraq and Afghanistan combined. But the financial cost has been even greater. The cost in the US has already exceeded that of all the wars the U.S. has fought over the last 50 years. And if an additional $3 trillion is approved by Congress, the cost will surpass that of World War II.

At this point, it is too early to predict how much the defense budget will draw down how quickly. Indeed, the shift might not occur immediately. Broadly speaking, two factors have historically had the most influence on defense spending: threats and affordability. Governments will all calibrate the relative importance of the threats they face against their new economic realities. In keeping with past patterns, countries may give most weight to threats, real or perceived, over the near term. If there are anticipated or ongoing conflicts, their defense budgets will probably increase. Over the longer term, however, economic factors tend to prevail, and governments may set defense budgets in line with their diminished resources. Either way, we face some tough decisions ahead.

John Dowdy is a senior partner at McKinsey & Co. He is based in London.

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