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AVIATION WEEK & SPACE TECHNOLOGY

HOW ISRAEL KEEPS ITS EDGE

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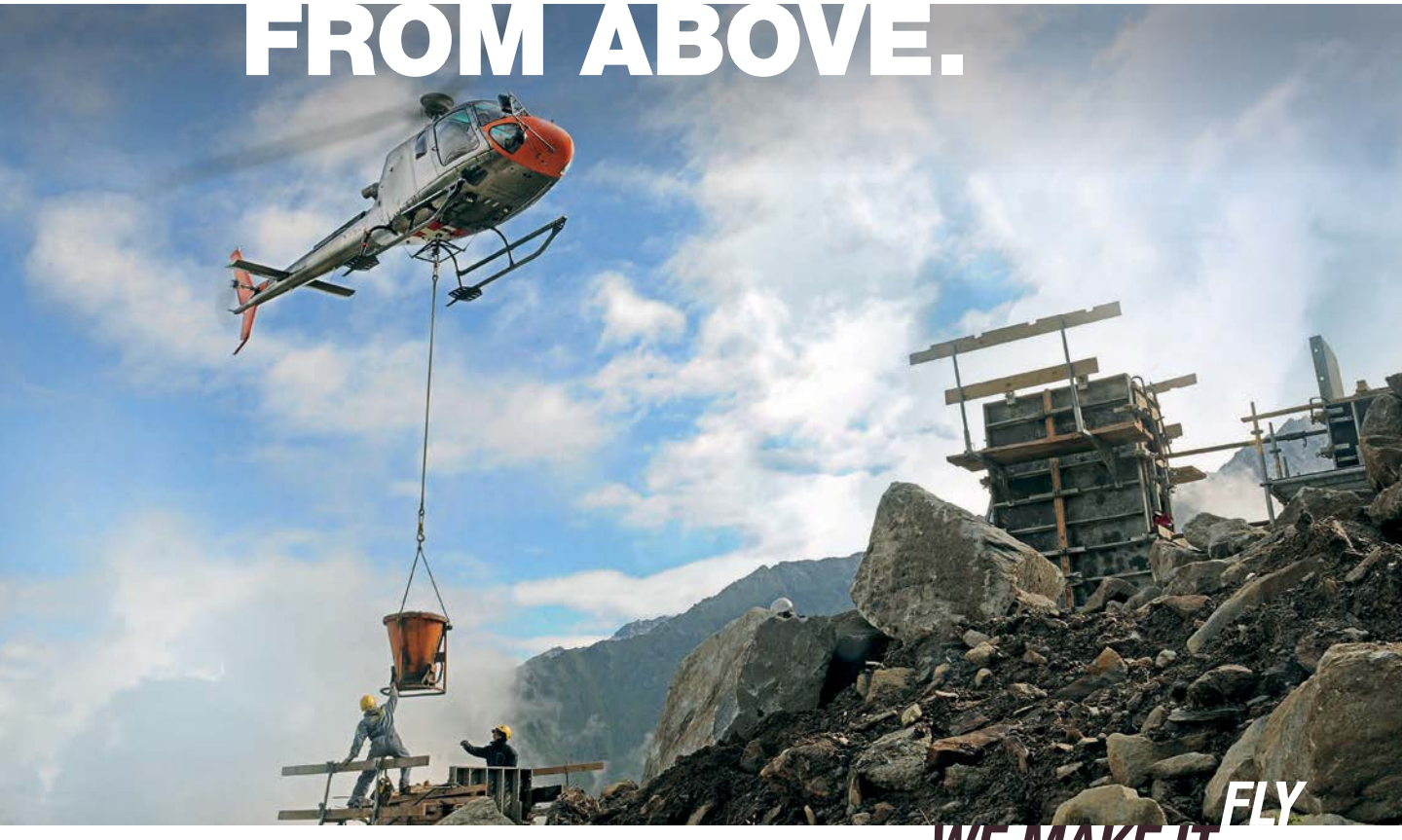
SOMETIMES DIFFICULT JOBS REQUIRE A LITTLE HELP FROM ABOVE.



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16 | *The Spitzer Space Telescope's observations were the first to reveal the smooth, bright ring of dust (in red) that circles the Sombrero galaxy and that the disk is warped.*

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VIEWPOINT

BEHIND THE SCENES

During a tour of Israel Aerospace Industries in early January, Defense Editor **Steve Trimble** visited "B3," the third and final prototype from the Lavi fighter program that Israel canceled in 1987 under heavy pressure by the U.S. For a snapshot of Israel's military technology base today, see our special report starting on page 52.

ISRAELAEROSPACE

ON THE COVER

Israeli Air Force fighters such as the Lockheed Martin F-35I are increasingly employing technologies that can conquer the essential challenge of modern warfare: How to choose the right weapon from the right platform within minutes? Defense Editor Steve Trimble's reporting, informed by a tour of Israeli aerospace and defense companies, begins on page 52. Photo by Amit Agronov.

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FEEDBACK

RISING ABOVE

Your article "CEO Shuffle" about Boeing *(Jan. 13-26, p. 22)* touches on a sign of the times with any corporation in flux as it evolves into the first half of the 21st century. But Boeing was caught not having a deep bench. Many line managers who came up through Boeing Commercial Airplanes are thought to be tainted by the 737 MAX.

The fixer CEO is going to have to be the "perfect Renaissance individual"—with a firm vision of Boeing for the future and a road map on how to lead the company there. The person will require an awesome set of interpersonal skills because they will need to repair the very tarnished reputation of Boeing as a company, heal the employees, fix the MAX, plan for a future new midmarket airplane and, most important, put the company back in the game of making trusted airplanes based on sound engineering design, vision, a command of innovation processes and a heck of a lot of luck.

David Calhoun may be that person, but he now has a "stale by" date on his head, with an urgency to perform miracles. As Socrates said: "Man must rise above the Earth—to the top of the atmosphere and beyond—for only thus will he fully understand the world in which he lives."

James Sherrard, Plano, Texas

MANDATORY MANUAL OVERRIDE

After reading "Boeing 737 Pilots Focus on Modified Procedures" *(Dec. 23, 2019-Jan. 12, 2020, p. 12)*, I think that if I were an airline pilot today, I might be seriously considering a career change. At the very least, a prerequisite would be flying aircraft with an absolute minimum of computer-controlled flight/cockpit management systems, where I would be able to quickly select full manual override by flipping a simple and intuitive switch.

All computer-controlled systems—whether for automated canned food production or flight management equipment—are software-controlled.

Experience has shown that software-code writers cannot be expected to think of every possible event that may require a predetermined set of instructions written into the program. No checklist can be created by fallible humans to ensure that every conceivable possibility has been envisaged and suitably prepared for within automated system instructions. If, on top of this, the selection of manual override itself entails a convoluted set of instructions, we have a recipe for disaster. In one report I read about the 737 MAX crashes, it appeared that manual override was possible only via a system that was an optional extra.

It is common knowledge now that airline pilot training entails more time devoted to learning to operate computerized cockpit systems and far too little time on basic stick-and-rudder flying. Some reconsideration is necessary on the topic of the flight control of commercial aircraft—and the training of aircrew. At this point, I am inclined to drive from point A to point B.

David Green, Thornhill, Ontario

A DISASTER WAITING TO HAPPEN?

Regarding "Nuclear Air Force?" *(Nov. 25-Dec. 8, 2019, p. 52)*, I have seen several mentions of compact nuclear power for remote military bases. This is insane. Has the military fought so many low-intensity wars that they forget the enemy sometimes shoots back? Now every base would be a Chernobyl disaster waiting to happen. A missile or anti-materiel sniper is all it would take.

Nuclear power is not a great idea anyway, but for remote military outposts, it couldn't get much dumber.

Dale Gibby, Columbus, Indiana

FREDERIC DEHAIS/ISAE-SUPAERO

BEHIND THE SCENES

France Bureau Chief **Thierry Dubois** experienced live electroencephalography while flying a Socata TB20 light single in Toulouse, to measure the workload on a pilot's brain during various phases of flight. His report begins on page 31.

ONLINE, the letter from the editor titled "After Muilenburg" *(Jan. 13-26, p. 66)* has drawn a number of comments:

JOSEPH.BRAUCH writes:
Well written article, sir. I have met Mr. Muilenburg on several occasions and will attest, he was great for Boeing. However, your assertion on the Boeing's culture is—in my opinion—the genesis of the problem. People preach culture . . . but they do listen when it really is time to listen. Speaking up against a seasoned executive at certain areas within Boeing will get one black-balled very quickly. The culture must change now.

MSAROFF opines:
McDonnell, an investment bank masquerading as an aviation company, took over Boeing with Boeing's money, largely as a result of government pressure to merge during the 1990s.

Stonecipher broke Boeing, and in order to fix it, it needs to go back to being what Boeing was, a group of engineers masquerading as a company.

The financial engineering, stock buybacks, etc., must end.

CORRECTION:

"Green Gambit" *(Jan. 13-26, p. 38)* should have identified the aircraft Boeing acquired from Air China and transformed into an ecoDemonstrator as a 777-200.

This correction was made to the article online and in the Aviation Week archive.

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

WHO'S WHERE

NASA has promoted **Robert Pearce** to associate administrator for the Aeronautics Research Mission Directorate. He was acting associate administrator and has held a number of strategic executive and program management positions at NASA. Pearce succeeds Jaiwon Shin, who has retired.

Wizz Air has hired **Jourik Hooghe** as executive vice president/chief financial officer. Hooghe had been with the Adecco Group. Wizz Air also promoted **Iain Wetherall** to chief investment officer, a new position; Wetherall was chief financial officer.

The Aerospace Corp. has promoted **Todd Nygren** to senior vice president of the engineering and technology group, which comprises 1,500 engineers and scientists. Nygren has held multiple leadership positions at the company including general manager and chief engineer for addressing emerging national security threats.

Northrop Grumman has promoted **Lesley Kalan** to corporate vice president and chief strategy and development officer. Kalan was vice president of government relations since Jan. 1, 2018, and vice president of legislative affairs since 2010.

The *American Enterprise Institute* (AEI) has named **Kori Schake** a foreign and defense policy studies director and resident scholar. She succeeds Danielle Pletka, who remains an AEI senior fellow focused on the Middle East and U.S. foreign policy. Schake was deputy director general of the International Institute for Strategic Studies in London.

Airbus has created a new communications and corporate affairs office whose leadership comprises: **Maggie Bergsma**, head of communications for commercial aircraft; **Yves Barille**, head of communications for helicopters; **Dirk Erat**, head of communications for defense and space; and **Philipp Encz**, head of the company's creative content teams and internal and external communications. **Guillaume Steuer** has been appointed head of external communications, reporting to Encz.

Safe Flight Instrument Corp., a lift-instrumentation and control-systems maker, has promoted **Maria Ferrara** to vice president of manufacturing, a new position, from director of quality assurance, during which she oversaw Safe Flight's AS9100 certification. Ferrara was BAE Systems' lead quality assurance engineer.

Virgin Galactic has hired **Michelle Kley** as general counsel, secretary and executive vice president of legal. Kley was senior vice president, chief legal/compliance officer and secretary at Maxar Technologies Inc.

Triumph Group has promoted **Thomas A. Quigley III** to vice president of investor relations and controller, from corporate officer and controller. He succeeds Michael Pici, who has left.

Airlines for America has named **Riva Khoshaba Parker** vice president of labor and employment/litigation. Parker had worked at the Office of the Judge Advocate General of the U.S. Army and helped create the Army's first nationwide labor litigation team.

Ulla Lettijeff has been appointed director of *Helsinki Airport* and a member of Finavia's executive group, effective Feb. 6. Lettijeff has held several managerial positions at Fiskars Group and Nokia.

The *DuPage Airport Authority* of West Chicago, Illinois, has named **Mark Doles** executive director. He succeeds David Bird, who has retired. Doles was interim executive director.

RTCA Inc. has made three board appointments: **Nathan Boelkins**, **Michael Ingram** and **Lorne Cass**. Boelkins heads Collins Aerospace commercial avionics; Ingram is vice president/general manager of Honeywell cockpit systems, and Cass is American Airlines operations/industry affairs vice president.

D. Scott Davis has been named independent lead director of the *Honeywell* board. He succeeds Enesa President/CEO Chico Pardo, who was lead director in January 2016-20.

The Aerospace Corp. has elected three new board members: former vice chairman of the Joint Chiefs of Staff U.S. Air Force Gen. (ret.) **Paul J. Selva**; former Defense Department official **Kathleen H. Hicks**; and Massachusetts Institute of Technology professor and former NASA official **Dava J. Newman**.

Platinum Tools has hired **Scott Lipsett** as marketing manager, succeeding **Jason Chesla**, who recently was named national accounts manager. Lipsett was brand manager at Reactor Watch. Before joining Platinum Tools as marketing manager in 2016, Chesla was a sales and marketing consultant at LiveWire Innovation.

Lufthansa has added a board-level position for customer and corporate responsibility, led by Brussels Airlines CEO **Christina Foerster**. It has also appointed **Thorsten Dirks** to head the new IT, digital and innovation department and **Harry Hohmeister** to lead the commercial passenger airlines division. Swiss International Airlines Chief Finanacial Officer **Michael Niggemann** has joined the board for three years and taken over management of human resources and legal affiars.

HONORS AND ELECTIONS

Makenzie Lystrup vice president/general manager of civil space at Ball Aerospace, has been elected a Fellow of the *American Association for the Advancement of Science* in recognition of her distinguished record in the fields of planetary science and infrared astronomy, science policy and advocacy, and aerospace industry leadership.

To submit information for the Who's Where *column, send Word or attached text files (no PDFs) and photos to:* **whoswhere@aviationweek.com** *For additional information on companies and individuals listed in this column, please refer to the* Aviation Week Intelligence Network *at* **AviationWeek.com/awin** *For information on ordering, telephone U.S.: +1 (866) 857-0148 or +1 (515) 237-3682 outside the U.S.*

FIRST TAKE

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COMMERCIAL AVIATION

Boeing is to start again with clean-sheet design of its next commercial aircraft, says President and CEO David Calhoun, revisiting its new midmarket airplane because of changes in the competitive playing field and a need to start with the flight control laws in the wake of the 737 MAX crisis (page 20).

Embraer is targeting entry into service by early 2026 for a turboprop airliner that would be developed under the planned joint venture with Boeing, says commercial aircraft President and CEO John Slattery.

As it ramps up single-aisle production to 63 a month from 60, Airbus is to build another final assembly line for the A321neo in Toulouse, in a plant created for the A380, production of which ends in 2021.

The FAA's certification process is not fundamentally flawed and "was followed" for the 737 MAX, but shortcomings in guidance, global perspective, safety assessments and agency staffing should be addressed, says an independent committee's report.

Israeli startup Eviation's prototype Alice all-electric regional airliner caught fire during ground testing at Prescott Regional Airport in Arizona on Jan. 23. Eviation believes a ground battery being used for the test caused the fire.

Japanese automaker Toyota has led a $590 million investment round at electric vertical-takeoff-and-landing air taxi startup Joby Aviation, contributing $394 million and its manufacturing expertise (page 15).

A modified A350-1000 performed automated takeoffs at Toulouse in December using a computer vision system as part of Airbus' Autonomous Taxi, Takeoff and Landing project.

Fluid- and motion-control systems supplier Woodward and materials leader Hexcel plan a stock merger to create one of the largest independent aerospace and defense suppliers (page 32).

International Airlines Group has protested to the UK government over assistance to regional carrier Flybe, describing the rescue effort for the Exeter, England-based airline as "a misuse of public funds."

U.S. NAVY

DEFENSE

Bell Boeing plans to deliver the U.S. Navy's first of 44 CMV-22B carrier onboard delivery tiltrotors to the HX-21 test and evaluation squadron in early 2020 after completing a first flight in December.

BAE Systems has proposed the $2.2 billion purchase of Collins Aerospace's military GPS business and Raytheon's airborne tactical radio division, to be divested as part of United Technologies' merger with Raytheon.

Leonardo has won another key U.S. defense program, receiving a $176 million contract on Jan. 13 to supply the U.S. Navy with 32 military trainer versions of the AW119 light helicopter.

Indonesian Aerospace rolled out an indigenously designed medium-altitude, long-endurace (MALE) UAV in late December. Two prototypes are to fly in 2020, with military certification planned for 2023.

The U.S. Air Force Research Laboratory's Generation Orbit X-60A hypersonic testbed has moved closer to flight after

VIEW FROM MONTREAL

Exit Signs at Bombardier?

Is Bombardier poised to exit aviation? First, the Canadian company handed a majority stake in its C Series (now A220) passenger jet program to Airbus. Then it sold off its storied regional aircraft business, leaving it focused on business aviation and rail transport.

The five-year turnaround plan led by CEO Alain Bellemare has shored up the company's liquidity and cash flow, but a surprise announcement has cast doubt on that strategy ahead of Bombardier's release of full-year results on Feb. 13.

The company says it is "reassessing future participation" in the A220 partnership and "actively pursuing alternatives" to accelerate paydown of its $9 billion debt load. "We speculate that the company may be looking at strategic alternatives that could include the sale of one of its two remaining divisions," National Bank of Canada Financial Markets analyst Cameron Doerksen wrote in a research note to clients. "The most obvious candidate would be its aviation business."

Airbus controls the A220 program, but Bombardier is on the hook for about 40% of its costs after it completes an investment commitment of $925 million. "Keeping up with the cost growth is probably not an option, and so it is likely Bombardier will exit the joint venture with only a fraction of the $2 billion at which it is currently valued," writes JP Morgan analyst Seth Seifman.

Whatever move the company makes will require the blessing of the Beaudoin family, which owns just 12.2% of Bombardier's equity but has 50.9% of voting rights through a special class of stock. "The Beaudoin-Bombardier family's views are a key variable in how this situation will evolve," Seifman says.

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FIRST TAKE

an integrated vehicle propulsion system test at Cecil Spaceport in Florida.

DYNETICS

Dynetics has conducted the first test flight of the X-61A Gremlins Air Vehicle under a DARPA program to demonstrate airborne launch and recovery of unmanned aircraft systems.

LEONARDO

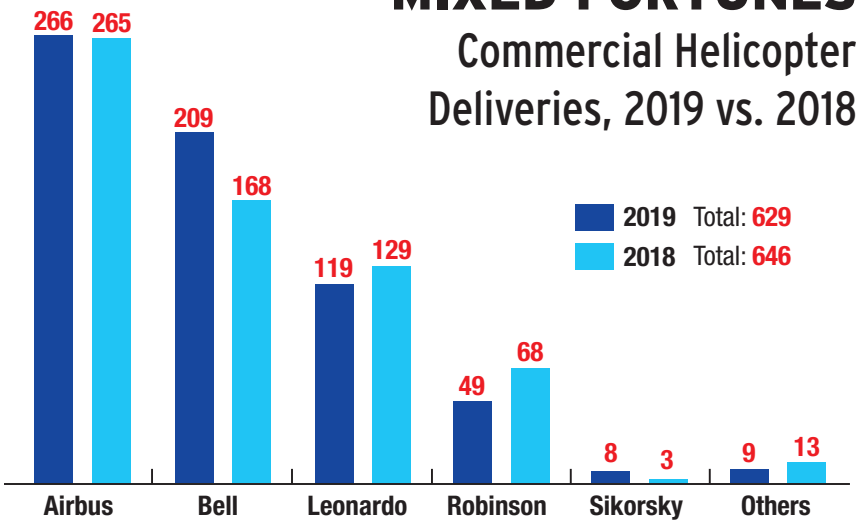
Leonardo flew its Falco Xplorer MALE unmanned aircraft for the first time on Jan. 15, from Trapani air base, Italy.

Lockheed Martin has won its sixth prime contractor role in a U.S. hypersonic missile program as DARPA has selected it to integrate and demonstrate the Operational Fires surface-to-surface weapon system.

Boeing, with the CH-47F, and Sikorsky, with the CH-53K, have submitted proposals for Germany's STH requirement for 44-60 heavy-lift helicopters to replace its CH-53G Stallions. The award is expected in 2021.

MIXED FORTUNES

Commercial Helicopter Deliveries, 2019 vs. 2018



Source: Daniel Williams/Aviation Week Intelligence Network

Airbus Helicopters held on to its lead in 2019, but Bell saw good growth as overall commercial turbine helicopter deliveries declined in 2019 amid a continued tough market for heavier aircraft. Our helicopter industry coverage begins on page 42.

DASSAULT AVIATION

France has awarded Dassault and Thales a contract to develop the Archange signals-intelligence platform. Based on the Falcon 8X business jet, three aircraft are to replace two C-160 Gabriel platforms.

SPACE

A SpaceX Falcon 9 lifted off from Kennedy Space Center on Jan. 19 and intentionally shut down 85 sec. later, setting the stage for a 131,000-ft. (40-km), Mach 2.2 test of the Dragon capsule launch escape system, the last major milestone before a crewed flight test to the International Space Station as early as April (page 37).

OBITUARY

Walter Boyne, prolific aviation writer/historian, died on Jan. 9 in Silver Spring, Maryland. He was 90. A U.S. Air Force bomber and test pilot from 1951-74, Col. Boyne was later appointed director of the National Air and Space Museum. He served as chairman of the National Aeronautic Association from 2006-14.

40 YEARS AGO IN AVIATION WEEK

The first test flight of the Ariane launch vehicle took place on Dec. 24, 1979, but it took more than a month for Aviation Week to publish photos. Our Jan. 28, 1980, cover featured a color image of the three-stage, all-liquid-fueled Ariane 1 lifting off from the European Space Agency's spaceport at Kourou, French Guiana. The mission successfully placed a test satellite in geostationary transfer orbit. Two months later, Arianespace was established as "the world's first commercial space transportation company," and in late 1981 received its first commercial launch contract from GTE Spacenet. Entering 2020, the company has launched 449 satellites over 40 years.

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

FAST FIVE WITH HONEYWELL

JOHN PETERSON
VP and General Manager
Software Services
Honeywell Connected Enterprise

John Peterson leads the software and services portfolio to create software solutions, cabin services and connectivity for aircraft and passengers.

Why don't airlines provide free Wi-Fi?

A. Current satellite capacity remains a precious commodity. High-definition products consume so much of that capacity that for all passengers to have a quality experience, there has to be some usage limits. We have developed creative ways to manage that capacity, so passengers can stay connected in a responsible way. By 2024-2026, there will be an exponential change in terms of capacity but also in passenger expectations. Airlines and aircraft operators that get the connected aircraft right will enjoy a competitive advantage.

Why is Honeywell an important technology player in aircraft connectivity?

A. When you talk to airliners or bizjet OEMs who want to make things more reliable, they turn to us because Honeywell is the natural fit for delivering a packet of data and getting it routed properly. That is a very complex, sophisticated pathway and Honeywell knows all the links along that path—sensors, data buses, routers, satellite links, global ground network and analytical tools to generate alerts or provide guidance on fixing problems. We have done unprecedented work over the past three years to pull that pathway together.

What is Honeywell Forge and how can it help airlines offer free in-flight Wi-Fi?

A. An airline has three key paths to be competitive and gain advantage—best ticket price, best on-time performance, best passenger experience, which includes connectivity. If there's a single thing that makes all three come together, that's data, data going through the aircraft network.

Honeywell designed the network in order to maximize the value it provides to operators. It provides better service to passengers and at the same time allows us to process important sensor data from the brakes, the APU and all the other aircraft subsystems. We aren't giving the airlines a terabyte of data on everything; we are giving them insight on the factors that drive their specific key performance indicators. The result is lower maintenance costs, reduced fuel consumption, fewer operational disruptions which all contribute to the passenger experience. That's all part of Honeywell Forge.

What does Honeywell offer to secure Wi-Fi connectivity for crews and passengers?

A. We're an innovator in how to handle cyber security using active onboard threat detection on the aircraft. Our surveillance software ensures that people getting on the aircraft don't bring along a device that has a bug that could affect other passengers and certainly not the flying system. When a threat is detected, we notify the airline's IT department, so they can decide how to act upon it. From there, we offer them the ability to shut down services, block devices and further filter or shape traffic, so people are less likely to do malicious or predatory things.

What do you believe 2020 will bring to the connected aircraft and the industry?

A. Ninety percent of our engineering hiring is in software. We are getting candidates who are finding how fun it is to be part of this as Honeywell shifts from a traditional industrial company to what you would only see in some of the most innovative software companies. We're going to bring forward a 500% to 700% reduction in cost to collect and offload data from aircraft.

With Honeywell Forge, all the connectivity pieces are designed to fi t together and deliver real value to the aviation industry. We have met with dozens of airline customers and hundreds of aircraft operators in 2019. Through their input, we continue to develop our platform and overall vision. Our customers have already started initiatives for 2020 which rely heavily on our new software platform, our connectivity hardware, and our services. It'll be a very exciting year for all of us and certainly an experience that few could have predicted even 18 months ago!

Learn more about Honeywell's initiatives here.

UP FRONT
KEVIN MICHAELS

MAX Production Shutdown

Which suppliers are **most vulnerable?**

BOEING'S SHUTDOWN OF 737 MAX production is the issue of the day for commercial aerospace. This decisive move, coupled with a company recommendation that pilots undergo full flight-simulator training prior to its return to service—and the fact that there are just 34 simulators in the global inventory—means we could be facing a production shutdown of at least 3-6 months. What are the implications for the supply chain? Which suppliers are most vulnerable and why?

Aerostructures, which has an estimated shipset value of $10-12 million on the MAX, is by far the most vulnerable segment. Profitability for these suppliers—typically in the single digits—is closely linked to production volume, and aftermarket revenue is limited. Spirit AeroSystems, which derives 50% of its revenue from making the MAX fuselage, has already announced layoffs of 2,800 employees at its Wichita facililities, with more to follow. Ducommun, which depends on the MAX for nearly 20% of its business, is another vulnerable Tier 1 supplier.

The real concern in aerostructures is with hundreds of subtier aerostructures suppliers, many located in the Wichita-Dallas/Fort Worth central U.S. aerospace corridor. OEM supply-chain initiatives like Partnering for Success have extended payment terms to 90-120 days or more. This effectively sucked the working capital out of many suppliers, making them highly vulnerable to production slowdowns. On top of this, Tier 2 and 3 aerostructures suppliers were tasked with capitalizing for a MAX production rate of 57 per month before the trouble began. We could see many failures here. This means Boeing and its major Tier 1 suppliers must establish a support program—perhaps maintaining low-rate production for the most vulnerable suppliers. Tier 4 raw material and forging/casting suppliers will also be affected. Moody's estimates that Precision Castparts derives more than 10% of its revenue from the MAX.

What about aero engines? CFM International joint-venture partners Safran and GE Aviation, which are not paid until engines are delivered, have effectively funded the Leap 1B engines produced since last March. CFM paid its suppliers along the way. While it is painful, Safran and GE can absorb a 3-6-month production halt. They have a healthy portfolio of military and business aviation engine programs, can shift production to the Leap 1A and derive most of their profits from the aftermarket. The production shutdown will actually stimulate aftermarket demand for legacy CFM56 engines, which could grow at a high-single-digit rate in the near future. Like aerostructures, the real concern in the aero-engine supply chain is with subtier suppliers. Many are highly dependent on the Leap programs, and they do not benefit from aftermarket profits.

737 MAX Supply Chain Vulnerability

Segment	Shipset Estimate (U.S. $ million)	Supplier Vulnerability
Aerostructures	$10-12	●
Aero Engines	7-9	◑
Systems	5-6	◔
Avionics	1.5-2	◔
Interiors	5-6	◑

SOURCE: AERODYNAMIC ADVISORY

Aircraft systems and components—hydraulic, fuel, pneumatic components and the like—are worth an estimated $5-6 million per MAX aircraft. Major suppliers include Collins Aerospace, Honeywell, Safran, Eaton Corp. and Meggitt. Like aero-engine OEMs, these suppliers support a diverse group of civil and military platforms and can lean on a healthy aftermarket revenue stream for profitibility. A typical component OEM derives 35-40% of its revenue from the aftermarket. Subtier suppliers making engineered components, forgings, castings and such could feel more impact than the OEMs in this sector.

Major avionics OEMs will be fine, as the majority of the MAX's avionics content is supplied by Collins and Honeywell. GE Aviation and BAE Systems are also notable avionics suppliers but part of much larger corporations. With a MAX avionics shipset value of $1.5-2 million, the loss of some $80-100 million in avionics demand per month will hurt, but avionics suppliers are less vulnerable than any other segment.

Finally, what about interiors and inflight entertainment? Major suppliers include Collins, Safran, Panasonic, Thales and Boeing itself. Like aerostructures, profitability is closely linked with volume, and losing 52 shipsets per month will be painful. Larger suppliers can handle a 3-6 month shutdown, but as in the aerostructures segment, subtier-parts suppliers are vulnerable.

In summary, a 3-6-month pause will yield carnage that Boeing and its Tier 1 partners must proactively manage to ensure production ecosystem viability. The irony of the situation is that since launching Partnership for Success in 2013, Boeing's relationship with its suppliers has been characterized more by conflict and unlilateral demands than partnership. Boeing CEO David Calhoun would do well to use this crisis as an opportunity to reset supplier relations to ensure long-term mutual success.

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GOING CONCERNS
MICHAEL BRUNO

A LITTLE MORE THAN TWO YEARS ago, then-Canada-based MacDonald, Dettwiler and Associates—better known as MDA—closed on its acquisition of U.S.-based DigitalGlobe and announced a major transition to a U.S.-headquartered space conglomerate focused on Washington customers. Analysts applauded the move as both transformational for MDA and one that marked the rise of the commercial space economy.

Star-Crossed

How MDA became **Maxar and then sold MDA**

So much for that idea. On the penultimate day of 2019, Maxar Technologies, as the company is now known, unveiled a deal to sell its MDA Canadian space subsidiary to a group of private equity investors led by Northern Private Capital for about $765 million.

No one saw that coming when MDA bought DigitalGlobe, itself the end result of a rollup last decade of commercial space imagery providers including GeoEye. Part of the investment proposal back then had been the combined company's breadth across space businesses, from building geostationary satellites for communications customers to providing intelligence photographs to the U.S. intelligence community. But the best-laid plans sometimes do not work out, and they certainly did not for MDA-turned-Maxar.

Instead, the sell-off serves as the climax of Westminster, Colorado-based Maxar's *annus horribilis*. A year that started with the loss of an anchor satellite and continued with sudden management turnover, layoffs and lingering doubts about whether geosat manufacturing would ever recover. By autumn, top executives were openly advertising that practically anything was for sale for the right price, as they sought to stabilize the corporation's balance sheet.

"We continue to get asked what else we might do; we continue to look at all alternatives," CEO Dan Jablonsky told an investor conference at the start of December. "We're not emotionally or religiously attached to anything in the business."

Long rumored, the MDA sale was no surprise. It includes all of MDA's Canadian businesses—once the company's core assets—encompassing ground stations, radar satellite products, robotics, defense and satellite components, representing 1,900 employees. It further entails certain radar-related imagery sales that have historically been included in Maxar's imagery segment.

"We think the recently announced MDA sale significantly derisks the Maxar story by meaningfully reducing the likelihood of a liquidity crunch," Credit Suisse analysts Rob Spingarn and Scott Deuschle said in a Jan. 15 investor note. Once closed, which is expected midyear, the roughly $765 million cash infusion should cut Maxar's debt load around 24% and bring its net debt-to-pretax-earnings ratio down to 5.24X from around 6.64X.

Weeks before, Maxar closed an expected sale-leaseback on its key campus in Palo Alto, California, for $291 million. The company signed a 10-year agreement to continue using the primary facilities there for satellite manufacturing, research and development. Palo Alto has been the home of Maxar's legacy SSL subsidiary.

"This transaction—when combined with the recently completed sale of real estate in Palo Alto—reduces Maxar's overall debt by more than $1 billion and significantly reduces Maxar's leverage ratio," Maxar Chief Financial Officer Biggs Porter said after the MDA announcement. "Also, the loss of future cash flow from MDA will be significantly offset by interest savings from the reduction of debt."

That may be so, but Porter was not kidding when he acknowledged the lost juice. Analysts called MDA a high-quality asset responsible for almost 11% of Maxar's annual revenue stream. And while the Palo Alto deal monetizes the property to pay for immediate demands, the company must pay to increase worker morale. About 16% of the original campus was sold a little more than year ago, and the employee attrition rate skyrocketed as high as 20% for obvious reasons. Attrition there since has dropped below San Francisco/Silicon Valley Bay Area averages, Porter said in early December.

"WE'RE NOT EMOTIONALLY OR RELIGIOUSLY ATTACHED TO ANYTHING IN THE BUSINESS."

– DAN JABLONSKY, MAXAR CEO

Nevertheless, no one involved in MDA or Maxar is likely to forget the past few years. "Over that two-plus-year period, we've seen extremes from the potential for great promise for the stock to points of despair, given what was perceived to be a debilitating debt load," said National Bank of Canada Financial Markets analyst Richard Tse.

Assuming the turnaround works, and Maxar goes on as a viable space services company, it will be interesting to see if there are lessons learned for the wider space sector.

For his part, Tse—perhaps the most well-acquainted analyst covering Maxar dating to its more humble MDA days—admits a reason to reassess. In a Dec. 31 investor note, he wrote: "The promise of synergies touted by the former merger definitely raises questions in regard to the strategic decision-making by the company."

LEADING EDGE
GRAHAM WARWICK

"CLOSER THAN YOU THINK" IS an unofficial mantra of the nascent urban air mobility (UAM) industry, and two events in the first weeks of 2020 underline the progress made in little more than a decade.

On Jan. 6, South Korean carmaker Hyundai unveiled its electric vertical-takeoff-and-landing (eVTOL) air taxi concept and a plan to invest $1.5 billion in UAM over the next five years. On Jan. 15, U.S. startup Joby Aviation revealed its production prototype and a $394 million investment by automaker Toyota, which will also provide its manufacturing expertise to the eVTOL developer.

For Uber, which ignited the eVTOL market in 2016 with its vision for the Elevate urban aerial ride-sharing service, the announcements are a major boost. Performance and noise figures from flight tests of Joby's all-electric aircraft show the vehicle capabilities required to begin limited commercial service in 2023 can be met with available battery technology. And involvement of two of the world's largest carmakers holds promise that urban air taxi operations can be scaled to large volumes beginning in 2025.

"Three years ago, we presented a crazy white paper here," Mark Moore, director of aviation for Uber Elevate, told the Vertical Flight Society's Transformative Vertical Flight conference in San Jose, California, on Jan. 21. "Today, we are right on target, executing exactly what we said in that white paper. Joby's stunning vehicle shows the capabilities we are after are very real."

But to ex-NASA eVTOL pioneer Moore, Hyundai's announcement may have even more significance. It was Google that began developing driverless cars, he points out. A handful of automakers then started working on the technology, and now the entire automotive industry is investing billions of dollars in self-driving vehicles. Within five years, he expects every carmaker to be involved in UAM.

Secretive Joby took an early lead in developing an eVTOL air taxi, using computer modeling and subscale prototypes to investigate dozens of configurations before settling on the S4 design, with its six tilting propellers, in 2014. The guiding principles were safety, low noise and minimum cost per passenger-mile, says founder and CEO JoeBen Bevirt.

Joby is the first eVTOL manufacturer to commit to deploying vehicles to meet Uber's 2023 target for beginning commercial service in pilot cities, and the $594 million Series C investment round led by Toyota will take the company through certification into production and putting initial vehicles into service, says Paul Sciarra, Joby executive chairman, early investor and Pinterest cofounder.

A demonstrator flew in 2012; Joby began flight-testing the S4 in 2017 and applied for FAA certification late in 2018. The 2.1 version now flying (pictured) "is near to the vehicle we want to operate," says Sciarra. The piloted five-seater has a cruise speed of 200 mph and a range of up to 150 mi. on a single battery charge. "We are not assuming any improvement in cells from what we are using now," he says.

Joby plans to own and fly the vehicles on behalf of Uber, under its own Part 135 air-taxi operating certif-

Credible Progress

Automaker involvement **boosts UAM prospects**

JOBY AVIATION

icate. "We are working on that already," says Sciarra. For both safety and customer adoption, the aircraft will be piloted. "It is not yet clear how fully autonomous passenger operations can be certified," he says. "We wanted to get out as quickly as possible before the rules are fully set."

Operating the vehicles "will allow us to bearhug the safety early on," says Sciarra. "We will be able to choose where and when to operate." The company is planning a production plant in Marina, California, and as the world's largest carmaker, Toyota will provide expertise in manufacturing, quality and cost control. Joby is already using robotic automated fiber placement to produce composite structures.

With its early market lead and a 150-mi. range, the company is looking at more than just urban trips—suburban, intercity and rural flights are within the vehicle's capability, says Sciarra. Acoustics are a high priority for community acceptance, particularly if flights move out from noisy city centers. A 60-dB noise level has been demonstrated, "but we need to continue to improve," says Bevirt.

THE LAUNCHPAD
IRENE KLOTZ

IT IS A LITTLE IRONIC THAT NASA'S Spitzer Space Telescope, the final member and least expensive of four so-called Great Observatories that have operated across the electromagnetic spectrum to expand humanity's view of the universe, is being decommissioned for lack of $14 million a year.

Launched on Aug. 25, 2003, the Space Infrared Telescope Facility, as it was originally known, joined the Hubble Space Telescope, the Compton Gamma Ray Observatory and the Chandra X-Ray Observatory in orbit, though it circled the Sun, not Earth.

Spitzer also was the only Great Observatory that did not launch on a space shuttle, the result of a redesign following the 1986 Challenger accident and subsequent ban of the liquid-fueled Centaur upper-stage engine—needed to put the telescope into its operational orbit—from the shuttle payload bay.

Slimmed down to fly on a Delta II, Spitzer nonetheless far surpassed its mission goals. From an Earth-trailing, heliocentric orbit, scientists had planned to use the telescope's infrared detectors to peer inside the veils of cosmic dust to study the early universe, galaxy and star-formation and protoplanetary discs that circle young stars.

They ended up doing all that and much more, including hunting extrasolar planets, the first of which were discovered only in the mid-1990s, as Spitzer was under construction.

"Because Spitzer was extremely well-designed, stable, reliable and capable of observing for days on end . . . it had tremendous impact on the study of exoplanets," says Project Scientist Mike Werner, with the Jet Propulsion Laboratory in Pasadena, California.

"We made the first detection of light from an exoplanet, the first measurements of molecules in exoplanets' atmospheres, the first measurements of energy transport on exoplanets, and we had some remarkable individual discoveries including the Trappist-1 system," which consists of seven rocky, Earth-like planets orbiting the same faint red star, Werner says.

Several of the Trappist-1 family orbit their parent star at a distance where liquid surface water is possible. "The Trappist-1 discovery was mind-blowing," Werner tells Aviation Week.

Another area where Spitzer had a major impact was the study of the very distant universe. Together with Hubble, Spitzer imaged the most distant galaxies ever found, objects that formed when the universe was about 3% of its current age. "They probably formed earlier, since by the time we see it the star population is somewhat mature," Werner says.

"It was really not expected that galaxies of this size would be present in such abundance in the early universe. Spitzer has seen a number of these objects, studied the properties of their stars," he adds.

Following a 2.5-year primary mission, Spitzer was given four extensions before losing funding priority. It won a final, one-year reprieve to continue operating through 2019 after technical problems delayed the launch of its successor, the James Webb Space Telescope.

NASA now plans to cease Spitzer operations on Jan. 30. Hubble and Chandra remain operational. Compton was deorbited in 2000 after one of its three gyroscopes failed, which had sparked concerns of an uncontrolled reentry over populated areas should another one falter.

NASA tried to find a private organization to take over Spitzer, but neither of the two proposals received had enough funding for operations, says Bill Latter, Spitzer program scientist at NASA headquarters in Washington.

"We had a party, and nobody came with enough money to buy a ticket," Werner adds dolefully.

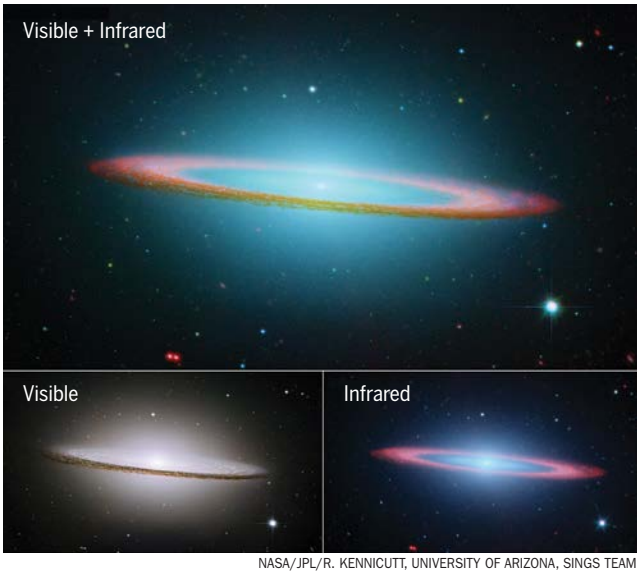
Annual operating costs are about $14 million a year.

Spitzer will be put into a safe mode but not deorbited, since it is so far from Earth and does not pose an impact or debris threat. Theoretically, it would be possible to restore communications with Spitzer, but "it would be difficult—and before long, impossible," because the telescope's antenna will no longer be pointed at Earth, Werner adds.

Shutting down Spitzer will not end its contributions to science. "We have a tremendous archive of more than 16 years of very high-quality infrared data, which is publicly accessible and for which NASA, in a competitive process, will award funding," Werner says. "People will continue to work on the Spitzer data for decades into the future."

Spitzer Shutdown

NASA pulls the plug on a **Great Observatory**



NASA/JPL/R. KENNICUTT, UNIVERSITY OF ARIZONA, SINGS TEAM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YEARS OF PAIN

> AIRLINES FORCED TO BRIDGE SUMMER WITH MASSIVE CAPACITY SHORTFALL

> SUPPLIERS HIT BY MAX PRODUCTION STOP > RECOVERY TO TAKE SEVERAL YEARS

Jens Flottau Dublin and **Sean Broderick** and **Michael Bruno** Washington

After AerCap CEO Aengus Kelly heard about the latest expected Boeing 737 MAX return-to-service delay, his schedule changed instantly. "I have met with all the big MAX operators in the last 72 hr.," he says. They were meetings of very, very unhappy customers, united by anger and uncertainty.

That the MAX grounding is now likely to extend another six months has huge consequences across the industry. Airlines must rearrange schedules again and endure another round of mass cancellations months after expecting the MAX to return, even in their worst-case scenarios. Lessors are struggling to deal with the fallout, unsure when they can get and place aircraft with customers. Boeing's suppliers also have almost no visibility on the schedule. There will be no Boeing narrowbody deliveries until the summer, and it is increasingly clear that it will take Boeing years to return to the production rates it had reached—and even longer to achieve the increased output it had targeted.

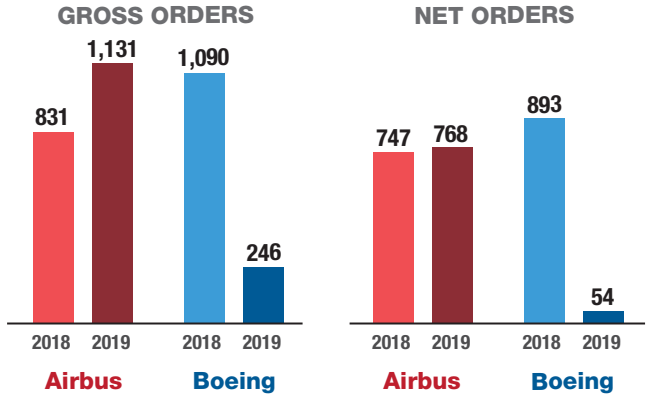
There is also growing uncertainty around some widebody programs, including 787 and 777 rates, and Airbus continues with production delays at its Hamburg final assembly lines. How many aircraft can and will be built and in what time frame will likely be open questions for years. The once clear path toward much higher narrowbody output is blocked for now.

"It is a big setback for airlines to have another summer gone," says Kelly about the expected new MAX schedule. "It is a very difficult situation for them." All have been selling seats based on now invalid capacity assumptions. As a consequence, there is big demand for lease extensions but hardly any dry-lease capacity available. Lessors with a MAX orderbook are in the same boat: It is "impossible to offer customers a slot" until Boeing sorts out the delivery stream, Kelly says. And he makes clear that "the damage caused to our shareholders has to be compensated by Boeing."

"Production will be reinvigorated . . . months before [anticipated FAA approval]," Boeing's new President and CEO David Calhoun said Jan. 22 during his first press conference. He mentioned June as a more specific target for anticipated FAA certification, before clarifying that he was "not going to give [out] a precise date."

The supply chain will come online even earlier as part of a slow ramp-up starting in the idled production line's first position and will include new processes put in place during the shutdown, Calhoun said. MAX production halted in January, 10 months after the fleet's mid-March 2019 grounding on the heels of two MAX accidents in less than five months.

Boeing's Bad Year



Note: Does not include ASC 606 revenue recognition standard numbers.

By the summer, around 800 aircraft will either be stored undelivered or never built as a consequence of the production stop. On top of that, almost 400 aircraft had been delivered to operators before the grounding. The resulting airline capacity gap will be well more than 1,000 aircraft by summer. There is little clarity on initial rates following the return to flight, with analyst estimates varying. One industry source believes Renton, Washington, can put out around 32 aircraft per month initially and step in five-aircraft-per-month increments every six months. Even so, Boeing would not return to an earlier rate of 52 aircraft per month until around the end of 2022. And some doubt that a target rate of 57 is achievable in the medium term, given uncertainty around demand and backlog vulnerability.

In the short term, not everyone thinks that missing the MAX fleet is a bad thing. "We were saved by incompetence," Avitas Senior Vice President Adam Pilarski said at the Airfinance Journal Dublin 2020 conference. Airlines would have operated "way too many aircraft" if all had gone according to the overambitious plan, he said, citing slowing passenger demand and the risk of overcapacity.

The MAX grounding has been "painful for all stakeholders," says Avolon CEO Domhnal Slattery, a major buyer of the aircraft. Like other lessors, Avolon has "PDPs [predelivery payments] sitting with Boeing not generating returns." However, Slattery considers the latest schedule announcement "the best news" coming out of Boeing in a long time because "I think we are getting near the end game."

When aerostructures giant Spirit AeroSystems announced job cuts due to the MAX production halt, managers noted further cuts could occur because of the MAX ramp-up

Boeing was forced to stop 737 MAX production in early January.

STEPHEN BRASHEAR/GETTY IMAGES

uncertainty. "Spirit has not received notice from its customer, Boeing, on how long the production suspension will last or what the production rate will be in the future," the Wichita supplier said Jan. 10. "Spirit believes that, when production resumes, the levels will be lower than previously expected due, in part, to the customer's need to consume over 100 MAX shipsets currently in storage at Spirit's facilities. In addition, Boeing has several hundred MAX airplanes built but not yet delivered to its customers."

Spirit had increasingly dialed back expectations for 737 production during 2019. By November, it did not expect to exceed a 737 fuselage production rate of 52 new units a month until 2022. Boeing had initially said it expected to reach rate 57 in late 2020. But those forecasts were issued before 737 work stopped completely and before the latest schedule shift.

Now financial analysts see a lower-for-longer production scenario. "Spirit basically just cut 21% of its workforce, and it certainly seems like production rates are going to be in the 40s for the next couple of years," says Michael Ciarmoli of SunTrust Robinson Humphrey.

Credit analysts think most of the supply chain is in for trouble. "Several companies face potentially significant earnings and cash flow pressures that could erode their liquidity in relatively short order," Moody's Investors Service said Jan. 10. How that slows future rate increases is anyone's guess.

Until the January stoppage, most of the supply chain had been buffered because Spirit and CFM International, the GE-Safran engine joint venture, had maintained production rates at 52 and 42 units a month, respectively. But the stoppage means all suppliers will share the pain, with little warning.

In turn, four of 24 suppliers rated by Moody's have been put on watch for credit downgrades. But "hundreds" more unrated suppliers around the world likely will feel the downturn. "The impact will be felt for many more months, though, as we expect a very gradual resumption of activity to pregrounding levels over an extended multiyear time frame," add Moody's analysts.

While the MAX problems are the dominating industry concern, they are not the only one. Sluggish widebody demand, exacerbated by several market-specific headwinds point to potential production-rate cuts for several Airbus and Boeing programs, a Bloomberg Intelligence analysis contends.

"The 787 is the closest to a cut and needs a book-to-bill of 1 in 2020, since airframers are typically comfortable with about three years of backlog," Bloomberg analyst George Ferguson wrote. Boeing has a backlog of 328 787s, the Aviation Week Intelligence Network's Commercial Aviation Fleet Discovery database shows, with a planned production-rate cut to 12 per month, from 14, later this year.

Widebody demand has been sluggish across the board, with Boeing and Airbus combining for about 200 net firm orders in 2019, compared to 419 deliveries. The figures will likely translate into a book-to-bill of about 0.5, even after Boeing finalizes its full-year firm order totals.

Boeing's problems are more acute than those of its European rival, thanks largely to the U.S.-China trade rift holding up sales to Chinese airlines. "Without China in the marketplace we have today, it's hard to see rate 12 being sustainable. . . . It wouldn't be a surprise if we saw it go to rate 10," Air Lease Corp. President and CEO John Plueger says.

The 777 program's monthly rate was adjusted to three from 3.5 as part of the bridge to the 777X, and some 777 freighters are being moved up in the production queue to help accommodate for delays in the 777X program. Boeing's notional plans are to ramp up the rate once the 777X is in service, but Ferguson said several factors could force the manufacturer to reexamine its strategy.

The A330 backlog appears solid at 331, thanks in part to an order for 40 A330-900neos Airbus booked in December and a production rate of four per month that has been in place for a year. But large exposure to AirAsiaX and Iran Air, a combined 35% of the backlog, is cause for concern, Ferguson said.

Airbus separately decided to build another final assembly line for the A321neo in Toulouse to be opened in 2022, a consequence of high demand and serious production problems at its Hamburg site. It is producing 60 single-aisle aircraft per month—split among Toulouse; Hamburg; Mobile, Alabama; and Tianjin, China—and is ramping up to 63 per month.

But even with the new line, overall single-aisle capacity in Toulouse will remain flat. Airbus already has two final assembly lines for the A320 in need of modernization. As the company adds A321neo capacity, it is upgrading the two legacy lines.

Unsafe Decisions

> NEW DOCUMENTS SHED LIGHT ON BOEING'S DECISION-MAKING

> BOEING DOWNPLAYED MCAS TO SKIP REGULATORY SCRUTINY

Sean Broderick Washington

Boeing knew in 2013 that introducing the Maneuvering Characteristics Augmentation System (MCAS) to the 737 MAX might trigger additional training requirements, so it made a decision: referring to MCAS internally was fine. But externally, particularly when talking with regulators, the MCAS would not be named, but rather described as an extension of an existing 737 system.

Four years later, when Lion Air was developing its MAX training program in preparation for accepting its first deliveries, the airline wanted to include simulator sessions for 737 pilots transitioning to the family's newest version. Boeing pushed back aggressively, arguing that Lion Air was burdening itself unnecessarily. Eventually, the airline relented.

The two scenarios, revealed in documents Boeing recently made public, are part of a growing pile of evidence being used to piece together how the MAX program ended up where it is: two fatal accidents, a grounded fleet, an idle production line, and no clear idea of when things will change. They also offer the clearest evidence yet that Boeing made some of its money-saving decisions despite having strong indications pointing to safer, more conservative options.

Boeing determined early on that ensuring 737 pilots could transition to the MAX without simulator time would be a huge cost advantage when pitching the model to customers. It also realized that regulators could consider the extent of the MAX's new features as too much to cover in computer-based training (CBT). The MCAS, a flight control law that commands automatic stabilizer movements in certain flight profiles, was chief among them.

A version of the MCAS was developed for the 767 tanker program, "but [treated as an] analogous function, as a speed trim-type function," a Boeing document summarizing a June 2013 MAX program meeting said. "If we emphasize MCAS is a new function, there may be a greater certification and training impact."

Boeing's solution: Refer to the MCAS externally as an addition to the 737 Speed Trim, not by its name. Boeing knew the approach might be questioned, so it sought input from its FAA-designated authorized representative (AR) "to ensure this strategy is acceptable" for certification, an internal email says.

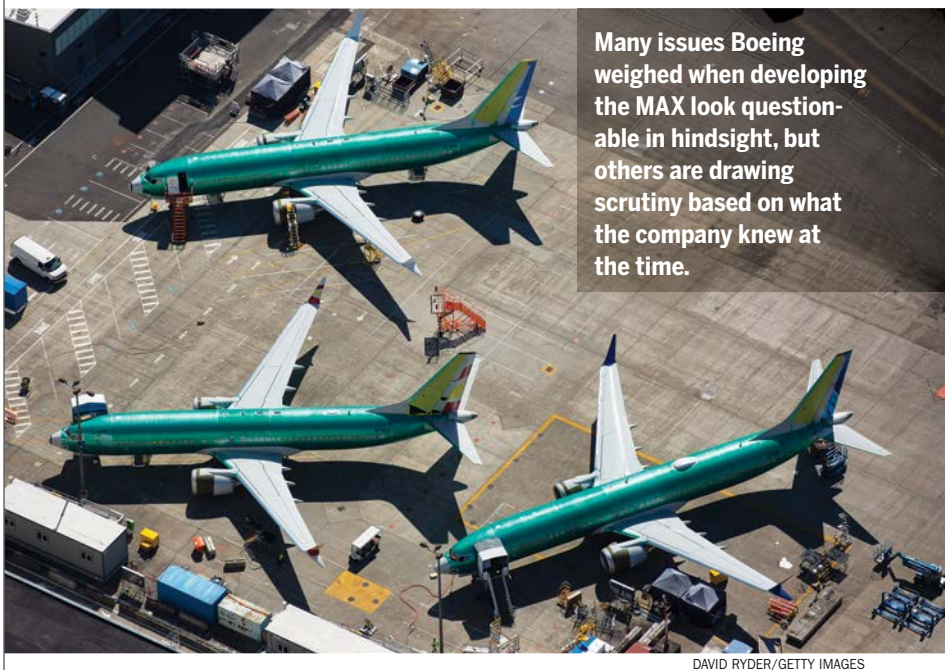
"After speaking with the [AR], concurrence was provided that we can continue to use the MCAS nomenclature internally . . . while still considering MCAS to be an addition to the Speed Trim function," the email says. "This will allow us to maintain the MCAS nomenclature while not driving additional work due to training impacts and maintenance manual expansions."

The plan extended to keeping mention of the MCAS out of MAX pilot training materials. Its erroneous activation played key roles in the two MAX accidents—Lion Air Flight 610 in October 2018 and Ethiopian Airlines Flight 302 in March 2019—that led regulators to ground the MAX in mid-March 2019. The fleet remains grounded while Boeing addresses regulators' concerns, including adding MCAS training and modifying the system's logic.

Most pilots did not know the MCAS existed until after the Lion Air accident. Boeing maintains that it kept the MCAS, designed to be transparent to pilots, out of manuals to simplify pilot training, and that an erroneous MCAS activation would be quickly diagnosed as a runaway stabilizer. The 2013 memo casts doubt on the former, and the two MAX accident sequences showed Boeing and regulators were wrong about the latter.

Boeing's efforts to win approval for simulator-free MAX transition training succeeded with FAA approval in August 2016, nine months before Malindo Air become the first customer to take delivery of a MAX. But some MAX customers and regulators were not convinced that CBT, or Level B training, would be sufficient. Among them: Lion Air and Indonesia's Directorate General of Civil Aviation (DGCA).

Lion Air was the first Asia-Pacific customer to order the MAX and would be one of the model's first operators. In June 2017, with its first delivery just days away, the airline was still developing its training curriculum, and simulator sessions were on the table. The airline's early entry-into-service



Many issues Boeing weighed when developing the MAX look questionable in hindsight, but others are drawing scrutiny based on what the company knew at the time.

DAVID RYDER/GETTY IMAGES

status meant other MAX customers would be monitoring its progress and fleet-related decisions, including training.

"I would like to discuss what if any requirements beyond the Level B CBT the DGCA has required of you, or if your airline has determined any additional training is required," a Boeing employee asked a Lion Air 737 training captain in early June 2017.

The captain replied that the airline "decided to give the transition pilot one simulator familiarization" in addition to CBT.

"There is absolutely no reason to require your pilots to require a MAX simulator to begin flying the MAX," the Boeing employee replied. "Once the engines are started, there is only one difference between NG [Next Generation] and MAX procedurally, and that is that there is no OFF position of the [landing] gear handle. Boeing does not understand what is to be gained by a 3-hr. simulator session, when the procedures are essentially the same."

The Boeing employee then listed six regulators that "have all accepted the CBT requirement as the only training required" to transition to the MAX. "I'd be happy to share the operational difference training with you, to help you understand that a MAX simulator is both impractical and unnecessary for your pilots."

In a subsequent email, the Boeing employee provided presentations on the MAX technical and operational differences for the Lion Air captain and his team. The Boeing employee also urged Lion Air to consider alternatives to simulator time, such as a flight-hour minimum in 737s or ensuring a pilot's first MAX flight is always done alongside a pilot with MAX experience.

The following day, the Boeing employee followed up, again pitching alternatives to simulator sessions. "I am concerned that if [Lion Air] chooses to require a MAX simulator for its pilots beyond what all other regulators are requiring, that it will be creating a difficult and unnecessary training burden for your airline, as well as potentially establish a precedent in your region for other MAX customers," the Boeing employee wrote.

Boeing in early January changed its position that 737 pilots do not need simulator sessions before flying a MAX. Its new recommendation—which the FAA says it will consider as it evaluates Boeing's proposed training revamp—is based on simulator trials last month during which some line pilots did not follow checklists during emergency scenarios. Changes to at least six checklists are among the updates Boeing is making to the MAX to satisfy regulators' concerns. It is also modifying the MAX's flight control computer software, including the MCAS.

FAA Certification Needs Adjustments, Not Overhaul

THE FAA'S CERTIFICATION PROCESS IS NOT BROKEN, BUT SOME LONG-standing guidance the agency and industry use needs updating, and product development should be done from a systems-safety perspective that better integrates design, operations and training. Those are the key takeaways in a final report produced by the Special Committee to Review the FAA's Aircraft Certification Process that examined the 737 MAX as a "case study," committee chair Lee Moak says.

Commissioned by the U.S. Transportation Department but left to reach its own conclusions, the committee spent more than six months evaluating the FAA's product-approval protocol. Its 68-page report includes 29 recommendations covering 10 findings.

Among the key ones: System Safety Assessments (SSA) need to be expanded "to better consider human–machine interaction," the report says. "The FAA should consider removing exclusions for skill-related errors associated with manual control of the airplane and ensure crew interaction with automated systems active in manual flight are systematically assessed."

Boeing's SSAs showing how pilots would react to a malfunction of the MAX's Maneuvering Characteristics Augmentation System were wrong. Boeing assumed pilots would identify the issue as a runaway stabilizer and react within seconds. But the crews involved in two fatal MAX accident sequences did not.

"[SSAs] should recognize that human errors are generally inevitable, and consider the consequences of an equipment failure compounded with a foreseeable human failure," the report says.

The committee recommended mandating safety management systems (SMS) for manufacturers to help them adopt a holistic approach to product development.

It also found that the FAA's certification process is too U.S.-centric. "The FAA should acknowledge the international profile of operators of U.S. State of Design aircraft and implement the necessary changes for its aircraft certification system to take into account differences in operations, training, and oversight across states," the report says. The agency is already making changes in this area by using 737 pilots from a variety of non-U.S. carriers to evaluate changes to the MAX flight control system logic and related training.

The committee urged the FAA to go further, codifying requirements directly in type certificates, similar to the European Union Aviation Safety Agency.

The committee also determined that certifying the MAX as a new design, rather than a derivative, would not have changed the outcome. It "would not have produced more rigorous scrutiny . . . and would not have produced a safer airplane," the report says.

"However, the committee concluded that additional consideration of the interface between the changed item and the rest of the system, as well as the impact of multiple changes over time, should be required," the report says. "This includes assessment of their combined effect on the flight crew's ability to safely manage operational tasks."

FAA Administrator Steve Dickson "welcomed" the recommendations, calling out the SMS and systems-safety aspects specifically.

Deja Vu

- HIGH-RISK AIRSPACE IS NOT ALWAYS FLAGGED
- OPERATORS ARE USUALLY LEFT TO MAKE THEIR OWN DECISIONS
- GLOBAL STATE COOPERATION REMAINS ELUSIVE

Jens Flottau Frankfurt and **Sean Broderick** Washington

The downing of Ukraine International Airlines Flight 752 (PS752) comes five years after a similar occurrence touched off calls for aviation and governments to improve at steering aircraft away from risky airspace. But the disaster underscores that clear deficiencies remain, and the loss of all 176 people minutes into a routine, scheduled flight has jump-started discussions about what to do next.

PS752 was hit by two ground-to-air missiles minutes after departure from Teheran's Imam Khomeini International Airport on Jan. 8. It took Iran several days to concede that someone in its Islamic Revolutionary Guard Corps (IRGC) had mistakenly identified the aircraft as a U.S. missile nearing Tehran—a scenario that IRGC was poised for in the hours after Iran struck U.S. facilities in Iraq.

Iran put its air defenses on high alert following its strike on U.S. forces, but did not shut down its airspace.

AKBAR TAVAKOLI/IRNA/AFP/GETTY IMAGES

The International Air Transport Association (IATA) called the event "an outrage" and demanded that "no effort should be spared to make sure that such a tragedy is never repeated." IATA Director of Aviation Security Matthew Vaughn adds that it was "shocking" that the governments of Iraq and Iran "failed across several [ICAO] Annexes by not providing any information to the airlines even many days after the event."

Tension in the region was especially high following the Jan. 3 U.S. strike on an Iranian military convoy near Iraq's Baghdad International Airport that killed IRGC Gen. Qasem Soleimani. Iran struck back in the early hours of Jan. 8, launching a ballistic missile attack from inside the country on U.S. forces based in Iraq.

The international aviation response was uncoordinated. Shortly after Iran's strike, the U.S. FAA warned civil aircraft to avoid the Baghdad Flight Information Region, which includes Iraqi airspace. (U.S. economic sanctions prevent its airlines from serving Iran.) Many international airlines continued to fly to Iran.

"The airport was fully operational, and there was no suspension from Iranian aviation authorities, no warnings," Ukraine International Airlines President Yevhenii Dykhne said Jan. 10. About 20 aircraft movements at Imam Khomeini took place after the Iranian missile strikes, and flights continued after PS752 was shot down.

It took the European Union Aviation Safety Agency (EASA) until Jan. 11—three days after the disaster—to recommend avoiding Iran overflights at any altitude. EASA has no mandate to force European airlines into action, which left carriers making their own decisions on serving Iranian airports. Most continued flights, despite seemingly apparent risks.

"Unfortunately, our flight was at the wrong place, at the wrong time," Dykhne says. "Any other aircraft could [have been] in its place."

EASA followed up on its initial recommendation on Jan. 16 with a more formal yet less stringent Conflict Zone Information Bulletin (CZIB), valid until July 16. "Due to the hazardous security situation, and poor coordination between civil aviation and military operations, there is a risk of misidentification of civil aircraft," it states. "Due to the presence of advanced air-defence systems, it is advised to be cautious with the risk associated to civil aviation. The risk to operations is assessed to be high for flight levels below 250." The original recommendation remains in place.

More than five years after the July 2014 downing of Malaysia Airlines Flight 17 (MH17) over Eastern Ukraine ignited global efforts to keep air transport flights out of high-risk airspace, there is still no infrastructure in place to guide airlines and civil authorities' fly/no-fly decisions. International Civil Aviation Organization (ICAO) guidance and international consensus is clear: It is up to states to protect aircraft in their airspace, even if that means closing it down, if risks warrant. But that does not always happen.

An ICAO information repository meant to support global analysis has been abandoned, and lead aviation authorities the FAA and EASA make their own judgments based on intelligence of varying quality. Many governments make no serious effort to participate in the process, even though they are responsible for their own air carriers' safety. Airlines are often left making their own calls.

"We have no trust in the intelligence our government provides," says an executive at a major airline. "There are no useful recommendations. Our decisions are all based on information gathered in informal networks." These unofficial links—between airlines or airlines and authorities—are considered the strongest source of information.

The situation varies from state to state. For instance, the U.S. typically has "great information-sharing" among intelligence agencies and aviation officials, says FAA safety chief Ali Bahrami.

Check 6 *Aviation Week editors discuss events surrounding the PS752 tragedy and what can be done to prevent similar future tragedies:* **AviationWeek.com/podcast**

But as political tensions between the U.S. and many longtime allies have risen, there is evidence of less cross-border intelligence-sharing, putting more of a strain on the informal networks tasked with filing in gaps.

"It is clear that we cannot rely on conflict-stressed states to restrict or close their own airspace," says European Cockpit Association (ECA) Secretary General Philip von Schoppenthau. "We must in principle rely on our national authorities and our airlines to make sure that the lives of passengers and crew are adequately protected and this unchecked risk is addressed. However, purely national, uncoordinated action has not done the job in the past and won't do it in the future."

Georg Fongern, head of security at Germany's pilot union Vereinigung Cockpit (VC), laments that the conflict-zone issue "has existed for decades" but prompted little meaningful action. "We have all known the risks, but the community has not had the courage to take painful decisions," he says. "There have been several shootdowns, and nothing has happened."

The Dutch-led probe into MH17 generated a series of conflict-zone recommendations. ICAO, prompted in part by the report, spearheaded development of a risk-assessment manual for operations over or near conflict zones. The guidance supports ICAO's foundational standards in its annexes, which all ICAO signatories have pledged to follow but do not carry legal obligation. The manual also notes that it does not "cover the risk that arises at lower altitudes (including during takeoff and landing phases) from short-range surface-to-air missiles"—precisely the scenario for PS752.

The manual was one of several high-level initiatives stemming from MH17. EASA held a conflict-zone workshop in December 2019 with government and industry experts participating. Three working groups were established to deal with three items: creation of a point-of-contact available 24/7 for airlines to get viable conflict-zone information, harmonization of terminology and the creation of an information-sharing mechanism that is open to all stakeholders. EASA says it is "now defining in more detail how an expert group comprising aviation stakeholders (EU national aviation authorities, airlines, representatives from EU institutions) could work together to improve information-sharing in a timely manner."

VC welcomes that idea, among others, because the EASA scheme appears to be open to stakeholders, including unions. IATA's Vaughan also sees the initiative as positive in principle but cautions that there are still governance and legal questions that need to be answered.

The ECA does not see a pan-European or international body forming to take on the role, meaning stakeholders must step up using the information they have. "What we urgently need is a method of sharing and acting, not upon closely guarded intelligence, but upon the outcome of risk analysis about conflict zones," says ECA President Jon Horne. "With these outcomes from different European airlines and states swiftly shared amongst each other and authorities, no European airline or pilot should be left in the dark—all have the opportunity to benefit from the effect of the privileged information of the best informed."

Airlines also are reassessing their position on what role they should play. "After MH17, there was a decision made to not get involved in the tactical level," says IATA's Vaughan. Members gave the association a more strategic mandate reflected in around 120 security standards to be met as part of the IATA Operational Safety Audit (IOSA). "Now the question is being asked again."

Notable Airliner Shootdowns Since World War II

July 23, 1954 Cathay Pacific Douglas DC-4 enroute from Bangkok to Hong Kong was shot down by Chinese Air Force Lavochkin La-7 fighters off the coast of Hainan Island. Ten on board died.

July 27, 1955 El Al Lockheed L-049 Constellation from Vienna to Tel Aviv, Israel, was shot down by two Bulgarian MiG-15s after straying into Bulgarian airspace. Fifty-eight crew and passengers died.

Feb. 21, 1973 Libyan Arab Airlines Boeing 727 from Tripoli, Libya, to Cairo shot down by two Israeli Air Force McDonnell Douglas F-4s. Five of the 113 on board survived.

April 20, 1978 Korean Air Lines Boeing 707 from Seoul to Paris was forced down by Soviet Sukhoi Su-15s near Murmansk after straying into Soviet airspace. Despite losing part of a wingtip to an air-to-air missile, the crew landed on a frozen lake. Two passengers died, but 107 survived.

Sept. 3, 1978 Air Rhodesia Vickers Viscount from Kariba to Salisbury was shot down by Zimbabwe People's Revolutionary Army (ZIPRA) guerrillas using a Strela 2 surface-to-air missile. Although 18 of the 56 passengers survived the crash, 10 were massacred by the guerrillas at the crash site.

Feb. 12, 1979 Air Rhodesia Vickers Viscount from Kariba and Salisbury was shot down by ZIPRA guerrillas using a Strela 2 missile. None of the 59 passengers or crew survived.

Feb. 8, 1980 Linhas Aereas de Angola Yakovlev Yak-40 shot down near Matala, Angola, with the loss of 19 passengers and crew, believed to have been fired on by a Zambian Shenyang J-6 (MiG-19).

Sept. 1, 1983 Korean Air Lines Boeing 747-200 enroute from New York to Seoul via Anchorage was shot down by a Sukhoi Su-15TM just west of Sakhalin Island after entering Soviet airspace. All 269 passengers and crew perished.

July 3, 1988 Iran Air Airbus A300B2 from Bandar Abbas, Iran, to Dubai was misidentified and shot down by a RIM-66 Standard surface-to-air missile from the U.S. Navy guided missile cruiser USS Vincennes. All 290 passengers and crew died.

Oct. 4, 2001 Siberian Airlines Tupolev Tu-154 was hit by an S-200 surface-to-air missile over the Black Sea enroute from Tel Aviv, Israel, to Novosibirsk, Russia. The missile was launched in error during a Ukrainian military exercise. All 66 passengers and 12 crew died.

Nov. 22, 2003 DHL Airbus A300-200F freighter was hit by a surface-to-air missile when enroute from Baghdad to Muharraq, Bahrain. Despite the loss of hydraulics, the crew managed a successful emergency landing, and there were no casualties.

July 17, 2014 Malaysia Airlines Boeing 777-200ER, enroute from Amsterdam to Kuala Lumpur, was hit over Ukraine by a Buk surface-to-air missile believed to have been launched by pro-Russian separatists. All 283 passengers and 15 crew were killed.

For now, one challenge remains even if changes are made: EASA's initiative is mainly regional, IATA initiatives would be sectoral – there is still no global system in sight that everyone contributes to and everyone can use. Given the politics involved and many other limitations, the industry may well have to live with the idea that there will never be one.

Ideally, VC's Fongern says, flight crews would get unfiltered information fast, even en route to a crisis zone, and be empowered by employers to act accordingly—and with impunity. "The captain's decisions have to be accepted."

NATO Works With ATC as Silent Flights Prompt Fighter Jet Scrambles

> MOST INCIDENTS CAUSED BY TECHNICAL ERROR

> NATO SEEKS CROSS-BORDER ARRANGEMENTS

Tony Osborne Brussels and Siauliai, Lithuania

NATO and Eurocontrol air traffic management are working to reduce the number of incidents in which fighters are scrambled in response to a lack of communications from commercial aircraft.

The alliance recorded nearly 500 so-called Comloss incidents within European airspace in 2019. Although the majority are resolved in minutes, around a sixth of those cases prompt the scrambling of fighters, equivalent to some 80 fighter launches a year.

Officials admit the number of incidents is small when compared to the increasing level of air traffic zipping through Europe's busy airspace: Around 30,000 flights are recorded daily. Launching a fighter aircraft is far from cheap, but it is often the only way to establish contact.

"Any incident is one incident too many, but when you look at the amount of air traffic, we are unlikely to reduce that to zero," says Lt. Gen. Klaus Habersetzer, commander of NATO's Combined Air Operations Centre (CAOC) at Uedem, Germany. The CAOC in Uedem is the location where NATO monitors military and civil air traffic in Northern Europe and where the decision is made to scramble fighters. A second CAOC, located in Torrejon, Spain, monitors the airspace across Southern Europe and the Mediterranean.

Comloss Incidents and Fighter Scrambles

Year	Number of Incidents	Number of Comloss-Prompted Fighter Scrambles
2019	489	80
2018	590	77
2017	816	82
2016	504	76
2015	470	79
2014	307	54

Source: NATO

"The good news is that in more than 90% [of Comloss incidents] it is pilot or technical error setting the wrong frequency," Habersetzer says.

Nonetheless, prolonged loss of contact can look sinister. After all, a loss of contact with four aircraft preceded the terrorist attacks on Sept. 11, 2001, as well as the loss of the Germanwings Airbus A320 in France in 2015, officials point out.

In one incident in December 2017, the crew of a commercial flight from Moscow to Milan was noncommunicative with air traffic control for 51 min. as the aircraft crossed the Czech Republic and Austria and headed into Italy, from where fighters were scrambled. Once the fighters were alongside the airliner, the crew quickly reestablished contact.

"The passengers didn't know the aircraft had been uncommunicative until the fighters were there," said one NATO official briefing journalists in Brussels.

Eurocontrol describes the Comloss incidents as a "disruption to the wider air traffic management system, and a waste of scarce national resources."

Together, NATO and Eurocontrol have established joint working groups to work on solutions to Comloss situations. Initial steps include an advisory campaign that is distributing lists of best practices and procedures for pilots and air traffic controllers who face radio communication loss.

Attention also is turning to the general and business aviation community. NATO has records of two incidents where the same private aircraft was intercepted twice in six days after being uncommunicative for nearly an hour.

The need for air policing is unlikely to go away, but countries are taking steps to share the burden.

Perhaps the most significant of these is the Benelux air-policing initiative, in which Belgium and the Netherlands take turns every four months to police the airspace of the two nations and Luxembourg.

"We were both facing aging and reducing numbers of aircraft which were sometimes operating really close to each [other] and doing the same mission for a small part of the NATO and national airspace," says Col. Geert De Decker, Belgian Air Force chief of staff.

The four aircraft on quick-reaction alert (QRA) are "isolated, and that is demanding on the fleet," De Decker says.

With shared air-policing responsibilities across three relatively small countries, the QRA fighters can reach anywhere in the three countries within a few minutes.

Few other nations in Europe have a relationship as close as the three Benelux countries, but Habersetzer is hopeful that future air-policing arrangements in Europe could allow fighters from one country to continue to intercept or shadow an aircraft in the airspace of another. "This would make it a lot easier for handover and takeover," he says.

NATO nations without combat aircraft to perform the air-policing mission rely on others to provide airspace security. For example, in Slovenia the mission is shared by the air forces of Hungary and Italy. The Italian Air Force also shares the air-policing mission of Albania and Montenegro with the Hellenic Air Force.

The mission in the Baltic States of Estonia, Latvia and Lithuania continues, with NATO countries providing detachments of fighters to Amari air base, Estonia, and Siauliai, Lithuania, for four months a year. Currently, the mission is performed by Belgium, as the lead nation, flying F-16s from Lithuania, while the Polish fly F-16s from Amari. Armed with beyond-visual-range and within-visual-range air-to-air missiles, the fighters have made regular intercepts of Russian military aircraft transiting from St. Petersburg to the Kaliningrad Oblast via the Gulf of Finland and the Baltic Sea.

Although the number of intercepts had tailed off this winter, the Belgian Air Force detachment has reported intercepts of fighter aircraft, strategic bombers and transports. The detachment also has had to deal with one commercial airliner that had been noncommunicative with air traffic control.

NATO aircraft intercepts reached 200 in 2019 according to NATO figures, the highest recorded figure since the Russian annexation of Crimea in 2014.

"By intercepting [Russian aircraft], we send a clear signal of being vigilant. That is good sign of deterrence and defense," Habersetzer says.

Change at the Top of IAG as Challenges Loom

> WALSH WILL STEP DOWN AS CEO IN MARCH AND RETIRE IN JUNE

> CURRENT IBERIA CEO WILL TAKE THE HELM

JOEPRIESAVIATION.NET

Helen Massy-Beresford Paris

Willie Walsh, the man behind the success of International Airlines Group (IAG) over the past decade, has announced he will retire in June, leaving his successor, Iberia CEO Luis Gallego, to manage the challenges that lie ahead for the airline group.

Walsh is a former Aer Lingus pilot who rose through the ranks to become the Irish carrier's CEO in 2001, then British Airways' (BA) CEO in 2005, and finally head of the group formed by BA's merger with Iberia in 2011, gaining a reputation for determination and straight talking along the way.

"Willie has been the main driver of this unique idea that is IAG," group Chairman Antonio Vazquez said Jan. 9.

Bernstein analyst Daniel Roeska agreed, writing in a Jan. 9 research note: "Under Willie Walsh's tenure at British Airways and IAG, the company has been transformed. He has overseen the integration of BA with Iberia, and then Vueling and Aer Lingus. The implementation of the holding company model has been a resounding success."

Walsh had already said in November that he planned to retire within the next two years, so the transition comes at a key moment for IAG, the parent company of British Airways, Iberia, Aer Lingus, Vueling and Level.

Appointing a company insider to succeed Walsh implies a welcome sense of continuity, Roeska wrote.

Like its European airline peers, IAG is taking steps to shore up its activities amid a tough environment for legacy airline groups—contending with geopolitical tensions and economic weakness, overcapacity, and fierce competition from low-cost carriers, not to mention the growing scrutiny of aviation's impact on climate change.

DANIEL LEAL OLIVAS/AFP-GETTY IMAGES

WORLD TRAVEL AND TOURISM COUNCIL

Willie Walsh (left), the architect of IAG, will be succeeded as CEO by Iberia chief executive Luis Gallego.

Gallego will now be the one to oversee IAG's €1 billion ($1.1 billion) purchase of Air Europa in a transaction that is set to be completed in the second half of 2020. The move is seen as a key strategic step for IAG, aimed at boosting its Madrid base to rival the biggest hubs across Europe.

Gallego said in November when the deal was announced: "This is of strategic importance for the Madrid hub, which in recent years has lagged behind other European hubs. Following this agreement, Madrid will be able to compete with other European hubs on equal terms, with a better position on Europe-to-Latin America routes and the possibility to become a gateway between Asia and Latin America."

The timing of the transition also makes sense given the Air Europa acquisition, Roeska added. "With the deal targeted to close in the second half of 2020, having a stable management team to oversee the integration should be preferred. Furthermore, this acquisition is being made by Iberia—and with Mr. Gallego moving up to the group CEO role, we would expect Iberia to have appointed and embedded a new CEO at the time when the integration work and synergy realization begins, hopefully minimizing disruption during that period."

Gallego will preside over the renewal of a large part of the IAG fleet.

Gallego is another aviation veteran: He started in the industry in 1997 with Air Nostrum and served as Iberia CEO since 2014, leading the airline's transformation and improvement to its finances over the years.

Gallego will also oversee a shift in the airline group's growth strategy. IAG said Nov. 8 at its capital markets day that it was revising its capacity planning downward for the next three years, revealing plans to grow capacity by an average of 3.4% in 2020-22. This growth figure is down from a previous target of a 7.4% compound annual growth rate and will lead to the group offering 13.3% less capacity in 2022 than it had originally planned.

The decision comes after the group already reduced its 2019 expansion. The original plan saw IAG's airlines offering 5.9% more capacity in 2019, but that was revised downward to 4% as general economic growth weakened.

Gallego will also preside over the renewal of a large part of the IAG fleet, with 51 long-haul and 92 short-haul aircraft set to arrive over three years.

In parallel, IAG—which has blazed a trail in the aviation sector with its airline holding model, in large part thanks to Walsh's efforts—is now being copied by others including Ryanair. IAG has also said it wanted to push for closer integration.

Walsh said Nov. 8 that responsibilities for some areas of the business such as pricing and revenue management, sales and distribution, loyalty programs and fleet planning would be transferred from the individual airlines to IAG itself. Network development will now be decided jointly with IAG, marking the next step in the development of the airline holding company's strategy.

Chinese Governments Expand Airline Investments

> ONE PRIVATE AIRLINE IS NOW UNDER FULL MUNICIPAL OWNERSHIP

> SETTING UP A NEW MAINLINE CARRIER IS NOW DIFFICULT

Bradley Perrett Beijing

Private ownership is a diminishing factor in Chinese commercial aviation—not because the central government is trying to stamp it out, but because the industry keeps drawing investments from supportive municipal and provincial governments.

In the past five weeks, one city has said it would take over an airline completely, a province has put money into another to persuade it to shift its headquarters, and two more HNA local carriers have become the group's latest to receive investments from their home municipalities. Injecting capital may become a more common way for Chinese local governments to back local airlines, since the central government is discouraging industry subsidies (*AW&ST* Dec. 23, 2019-Jan. 12, 2020, p. 106).

NANSHAN GROUP

Qingdao Airlines has been taken into complete public ownership, part of a Chinese trend to support local carriers that help local economies.

Qingdao Airlines is the carrier that has been taken into complete public ownership. The government of its home city, Qingdao in eastern China, is using a subsidiary to buy the airline along with the other aviation assets of the private Nanshan Group, including business aviation operator Nanshan Jet.

The reasons for the 6.85 billion yuan ($983 million) acquisition have not been stated, but the five-year-old airline has reported a profit only once, for 2017. Any Chinese municipal government would be alarmed at the possible closure of a local carrier, because air links are valued for helping to promote economic growth. Qingdao Airlines has 25 Airbus A320s, of which 17 are leased.

The city was a shareholder in Qingdao Airlines when it began flying in 2014. The city and another official shareholder, Shandong Airlines, sold their shares in 2015 when Nanshan Group was embroiled in a corruption scandal.

One stimulus for municipal investment is the risk that a local carrier could be rustled by another government offering capital and support. That happened with privately owned Air Travel, an airline formerly based in the southwestern province of Yunnan. It has moved to Changsha, the capital of Hunan, following investment from that province.

Hunan has become a 26% shareholder in Air Travel, the national corporation registry shows. Travel specialist Tongcheng Group retains the largest holding. The transaction was completed in December.

Hunan and Changsha are in the south-center of China's main population zone. Air Travel has 12 aircraft of the Airbus A320 family in four versions, including three A320neos. The registered capital of Air Travel has risen by 694 million yuan, presumably the amount invested by the province.

Announcing the transaction in September, the government said it aimed to develop Changsha Huanghua International Airport as a hub for central China. The provincial and municipal governments covering Wuhan and Zhengzhou, cities to the north of Changsha, have similar aims for their main airports. Until 2016 Hunan could have gained a new airline by offering capital and other incentives to an airline group, typically HNA, to establish one. But the Civil Aviation Administration of China now is disinclined to license new mainline passenger carriers.

Faced with the same problem, Tongcheng bought control of Hongtu Airlines in 2017, changing the brand to Air Travel. The group, which has a travel agency, aims to copy the model of Spring Travel, which set up budget carrier Spring Airlines in 2005. Spring's agency business feeds traffic to its sibling airline.

Under the Hongtu name, Air Travel began flying in 2016 with an Airbus A321. It aimed at the tourism market in Yunnan. A few months before Tongcheng bought control of the airline, the group made early moves to set up a regional carrier. That apparently has not proceeded, though Tongcheng has not said it has given up.

In 2018 HNA began relinquishing shareholdings in airlines it had set up for and with local governments, though it is not always clear whether new government money has gone to the group or has simply strengthened the carrier in question. Although HNA has been under severe financial pressure, industry officials say it has excellent relations with the many Chinese provincial and municipal governments for which it has set up airlines. And those governments are often keen to provide further support for what they see as their airlines.

The latest such transaction is a "shareholding reorganization" of HNA's Air Guilin with the government of its home city, Guilin. The municipality will become the indirect majority owner of the airline. HNA will continue to supply managerial staff, the parties say.

The arrangement is similar to a capital reorganization of HNA's West Air announced on Dec. 2. In that case, the government of the airline's hometown, Chongqing, agreed to increase its shareholding to at least 70%. Again, operations remain an HNA responsibility. West Air says it has four Airbus A319s and 31 A320s, which operate 114 routes serving 51 cities.

Malaysia Faces Lengthy Process to Regain FAA Rating

- MALAYSIA IS THE LATEST ASIAN NATION HIT BY FAA DOWNGRADE
- FLAWS FOUND WITH REGULATORS, BUT RESTRICTIONS APPLY TO AIRLINES

Adrian Schofield

Aviation oversight deficiencies are once again under the spotlight in Southeast Asia, as Malaysian authorities consider how they can convince the FAA to reverse its downgrade of the country's safety rating.

Malaysian leaders recognize the importance of restoring the FAA safety rating and are calling for urgency in addressing problems. However, the recent history of similar downgrades in Asia shows that gaining an FAA upgrade can take years. And while the FAA's assessment applies only to the regulator, it is the airlines that suffer the commercial consequences.

The FAA announced in November that it would downgrade the safety rating of the Civil Aviation Authority of Malaysia (CAAM) to Category 2, after determining the CAAM did not meet International Civil Aviation Organization (ICAO) safety standards. The FAA conducted an audit in Malaysia in April 2019, under its International Aviation Safety Assessment (IASA) program.

IASA enables the FAA to evaluate the oversight capabilities of countries that have airlines either serving the U.S. or codesharing with U.S. carriers. National regulators found to be in full compliance with ICAO standards are rated Category 1, while those that are not are classified as Category 2. Currently seven are in the latter category.

When a country is designated Category 2, its airlines cannot add or start service to the U.S. While they can maintain existing flights, they cannot change to a different aircraft type and are subject to heightened surveillance by the FAA. There are also certain restrictions on codeshares with U.S. airlines.

The FAA assigned a Category 1 rating to Malaysia in 2003. The reassessment was conducted in April 2019, and a meeting with the CAAM was held in July to discuss the results. The FAA has not publicly released specifics of its findings, but said the Category 2 rating means the CAAM "is deficient in one or more areas, such as technical expertise, trained personnel, record keeping, and/or inspection procedures."

Other Southeast Asian nations have been downgraded by the FAA in recent years, including Indonesia, the Philippines and Thailand. Indonesia was restored to Category 1 in August 2016, after being downgraded in 2007. The Philippines was reduced to Category 2 in 2008 and upgraded in 2014. Vietnam was granted Category 1 status in February 2019, although this was not technically an upgrade since it had not previously been classified by the FAA.

Thailand is still attempting to regain FAA Category 1 status. The country's oversight agency was downgraded in late 2015. Thailand was also put on ICAO's "red flag" list, which prompted other nations to impose restrictions on Thai carriers. The ICAO warning has since been removed, but Thailand remains in the FAA's Category 2.

Malaysia's case is a little different from Thailand's, as it has not been red-flagged by ICAO. The CAAM has stressed that it is "fully in compliance with all ICAO standards and legislation," having been audited by ICAO as recently as the middle of 2019. However, the CAAM also acknowledges that the FAA is "within its rights" to make its own assessment of compliance.

The CAAM says it has asked the FAA to conduct a reassessment within the next 12 months. "Plans are already underway to address the findings of the [FAA] audit," according to a CAAM statement.

The Malaysian regulator says it "takes the FAA's assessment constructively and has moved to make serious changes in its structure and operations." The CAAM's CEO resigned just before the downgrade, and a committee has been established to oversee the authority's operations.

"Some shortcomings do exist" in its role as aviation regulator, the CAAM admits. It notes that the FAA audit covered areas such as legislation, oversight, delegation of authority and the number of technical personnel employed.

Malaysia-based carriers such as AirAsia X have restrictions imposed on adding or changing service to the U.S. after the country's regulator was downgraded by the FAA.

TENGKU BAHAR/AFP-GETTY IMAGES

In one early move, the government has merged the CAAM with the Malaysian Aviation Commission, which is the economic and commercial regulator. This merger will give the CAAM more financial independence and help it hire more technical employees, says Transport Minister Anthony Loke.

The only Malaysian carrier with direct service to the U.S. is AirAsia X, which has a flight to Honolulu via Osaka, Japan. The airline confirmed it will maintain this service. AirAsia X has previously discussed serving the U.S. mainland with Airbus A330neos, but any such plans would be delayed by the FAA downgrade.

While the downgrade is "disappointing," AirAsia X will "remain committed to supporting CAAM and our industry colleagues in developing and maintaining the highest safety standards," the airline's CEO Benyamin Ismail says. "By keeping the lines of communication open with regulators and industry, we are confident that Malaysia will soon restore its Category 1 rating," he adds. The airline stressed it has achieved accreditation under the International Air Transport Association's Operational Safety Audit (IOSA) program.

Malaysia Airlines does not serve the U.S. with its own flights. It relies on its partners to provide codeshare access to the U.S., particularly through fellow Oneworld member American Airlines. However, this arrangement has changed due to the FAA downgrade. American has stopped codesharing on Malaysia Airlines flights, as required by the FAA, although the Malaysian carrier can still codeshare on American Airlines flights.

Like AirAsia X, Malaysia Airlines says it will "give its full support to CAAM to [restore] its rating to Category 1." The airline has been "continuously and successfully recertified" under the IOSA program since 2005. Malaysia Airlines also holds maintenance, repair and overhaul approvals from the European Union Aviation Safety Agency and the FAA. All companies in the airline group "consistently subject themselves to various audits to ensure they are [on] par with international best practices in all aspects of safety management," the carrier says.

The CAAM could face a multiyear process to address the FAA's concerns and restore the country's safety rating, warns Andrew Herdman, director general of the Association of Asia Pacific Airlines.

While the FAA has not publicly revealed its specific areas of concern regarding the CAAM, recent experience with downgrades of other nations shows that "whatever the [FAA's] findings are, remedying them takes time," Herdman tells Aviation Week. Malaysian regulators are showing urgency in starting to address the FAA's concerns, but "realistically it takes a year or two, or maybe longer," he says.

When other Asian countries have been affected by FAA downgrades in recent years, their regulators have often needed major changes in legislation, procedures, staffing and resources. Factors such as these "are not easily fixed in the short term," says Herdman.

Increasing the number of trained and qualified staff can be a particular problem for aviation regulators. Herdman notes that oversight bodies are generally competing with airlines for the same personnel, and rapid growth in the region's aviation industry has reduced their availability. Even when a country's aviation industry is thriving, its regulators can still face resource and manpower issues, Herdman explains. This can lead to oversight not keeping pace with industry growth.

Although the downgrade applies to the regulator, it is still "commercially damaging to airlines," Herdman says. For example, restrictions on codeshares with U.S. airlines have marketing and revenue implications. There is also the risk that other jurisdictions may take the FAA findings into account when considering applications for new service from Malaysian carriers.

Airlines are usually eager to help their national authorities regain FAA Category 1 status, Herdman says. In some cases, carriers have financed external experts to come to their countries to advise the regulatory bodies or to second their own qualified staff. However, Herdman stresses that it is ultimately the governments and regulators that have to be responsible for improving oversight and providing sufficient resources.

Death Claw Shows Path to Faster Development

> U.S. AIR FORCE DEVELOPING AUTO-GUNNERY MODE FOR F-16s

> TWO-YEAR-OLD DEMONSTRATION PROVED ACCURACY IMPROVEMENT

Steve Trimble

A 40-year-old idea to improve strafing accuracy by transferring flight control of a manned fighter to the autopilot to aim the gun is being revived as the U.S. Air Force looks internally for innovations that can be demonstrated and delivered quickly.

An operational version of the Digitally Enhanced Aiming Through Control Law (Death Claw) system is in development less than two years after the U.S. Air Force Test Pilot School conceived and performed an eight-month demonstration.

In effect, Death Claw has two functions. As a new automated flight mode, it solves a practical problem for pilots of F-16s and potentially other fly-by-wire fighters. The system also highlights a path to introducing aircraft upgrades faster by involving the test community up front.

U.S. AIR FORCE

Flight tests showed aircraft-pointing accuracy improves significantly when Death Claw is engaged (left) compared to pilot control.

The practical problem has been known for decades. Like any modern fighter, the F-16's sensors and flight computer can precisely calculate where the F-16 needs to be pointed for the 20-mm rounds from the fighter's M61 cannon to hit a moving target in the air or on the ground. But the computer still relies on the human pilot to accurately point the aircraft at the spot indicated on the gunsight-piper on the head-up display.

The answer seems obvious. Add an "auto-gunnery mode" to the flight control law, and allow the autopilot control to point the aircraft when the gun is engaged. Bill Gray, chief test pilot of the test pilot school, launched a demonstration program in late 2017 to prove it could work.

"Some of our engineers were chatting about how it would be cool if an autopilot could aim the gun," Gray says.

The test pilot school owns the F-16 Variable stability Inflight Simulator Test Aircraft (VISTA), an aircraft specially modified to allow inflight changes to the flying qualities. "I realized it would be a relatively simple modification to adjust the control of that airplane to actually test this to do the concept exploration," he says.

The Death Claw demonstration conducted 12 test flights in November 2017-January 2018. The Air Force compared the accuracy of autopilot-controlled gun firings to pilot-controlled shots. The F-16 VISTA lacks a gun, but accuracy was calculated based on how closely the aircraft was pointed compared to the gunsight-piper. In almost every attempt, the autopilot proved more accurate than the pilot at aiming the aircraft.

"To a P-51 pilot, the gun was precise, it was your precision. Well, now the gun is the least precise weapon on the F-16," Gray says. "Death Claw was basically a project to make the gun a precision weapon."

In the process, it showed a different way of approaching innovation. The idea was conceived at the test pilot school rather than at the Air Force's laboratories, which, in fact, experimented with similar concepts in the early 1980s.

The Air Force is growing impatient with decades-long development programs. Acquisition leaders are calling for ways to compress the development phase for upgrades and new platforms. The Digital Century Series launched in October is even seeking to invent a development process that could field advanced new capabilities within five-year increments. As much as the Air Force pushes to accelerate development, the question still remains how much schedule compression is possible during the test-and-evaluation phase.

In the case of Death Claw, the test pilot school used a live demonstration to prove a basic autopilot capability. Lockheed Martin's Skunk Works is now working on an improved operational version of the new autopilot gunnery mode, but the Air Force collected the data it needed to make a decision with a rudimentary system created within four months in 2017. The test community also now has experience with the technology, which could help focus the follow-on test schedule

"Bring the test enterprise in early, so that we can help define what those questions are that we have to answer," says Col. Mark Massaro, chief of the Air Force's test and evaluation group's policy, programs and resources division at the Pentagon. "If you make your design consider these particular things, you might be able to get a better design coming out of it, or you may be able to help testing go quicker, because you're designing in the ability to get the data that we need out of it during design."

Eye-Tracking System Seen as New Aid for Pilot Training

> LAB SPINOFF OFFERS TOOL TO ENHANCE SIMULATOR SESSIONS

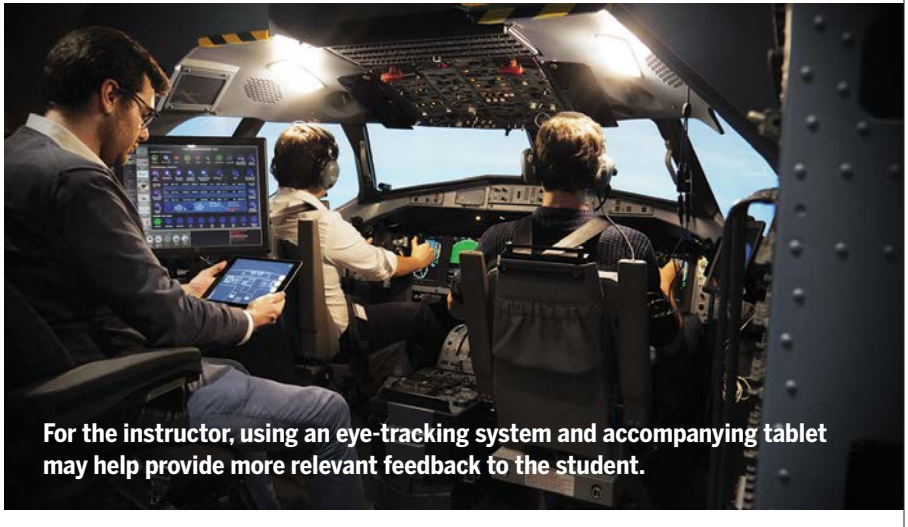
> EYE-TRACKING TO BECOME WIDESPREAD IN DAILY LIFE

Thierry Dubois Toulouse

After a training session in a flight simulator, the instructor gives critical feedback to the student pilot. Depending on the appraisal, the student may gain self-confidence, correct errors or pass an exam. However, as with every human-to-human process, it is not perfect.

Sometimes, the instructor notices the student has failed to complete a procedure but the student is adamant he or she has checked every item. Sometimes, a mistake goes unnoticed.

HINFACT



For the instructor, using an eye-tracking system and accompanying tablet may help provide more relevant feedback to the student.

Hinfact, a startup company created as a spinoff from a research laboratory in Toulouse, may have developed a solution with its Gazecraft system. The solution makes the most of eye-tracking, thanks to systems that are increasingly cheap, easy to install, and accurate and reliable. Gazecraft is part of a trend in which new tools may make training more effective. And at a time when the global demand for pilots is growing, the tools may be adopted quickly.

Gazecraft monitors the pilot's adherence to a procedure. The system can notice the absence of a control input, a forgotten gaze at an instrument or a missed callout to another crewmember.

Hinfact's Gazecraft system also marks the success of eye-tracking, whose utility may just be beginning to be seen. Some examples include: game consoles and inflight entertainment systems that include eye-tracking and high-end cars that use eye-tracking systems to detect distraction. L3 has delivered simulators with eye-tracking systems for the use of head-up displays.

The laboratory in which Hinfact was born is the neuroergonomics and human factors department of the ISAE SupAero, or the French national higher institute of aeronautics and space's engineering division. Frederic Dehais, head of the department and a Hinfact co-founder, received a Laureate Award from Aviation Week in 2019.

Gazecraft's designers strived to alleviate the instructor's workload. A high level of automation for watching students was devised to help the instructor make relevant comments after a 4-hr. training session.

Using a tablet, an instructor can bookmark an event for reference during the post-training discussion.

After the session, the instructor can replay a sequence to show the student missed a step. They use recorded facts as opposed to subjective memory. The "H" in Hinfact stands for "human," says co-founder and Chief Technology Officer Thibault Vandebrouck.

The word's similarity with "hindsight" was not intended but makes sense.

Dehais' team participated in a wide-ranging experiment led by the BEA, the French bureau of air accident investigations, in 2012-13. It focused on the loss of situational awareness during an unexpected go-around. It was one of the first major studies that underlined the role of eye-tracking in understanding a pilot's behavior and possibly improving human performance.

The BEA and its partners documented situations when pilots no longer cooperate or monitor the aircraft's speed. Thanks to eye-tracking, "the pilot could take a step back and reflect on his ocular strategy," says Vandebrouck. The BEA recommended OEMs study visual patterns to improve cockpit procedures.

Hinfact's target customers are carriers and training centers. Gazecraft can be customized at the user's level.

If a number of students fail in a given procedure, the chief instructor will be notified, and the procedure may be questioned.

Vandebrouck hopes to sign the first sales contract in the middle of this year. Thus far, some revenues have come from airlines that have integrated Gazecraft into simulators for evaluation purposes. "Integration is a lot of work," says Vandebrouck. "We have to install the cameras and stream the simulator's data to our system."

One of Gazecraft's main design drivers is the need to monitor a behavior, he emphasizes. The interface therefore was made as straightforward as possible. In contrast, a comparable tool designed by Thales for helicopter pilot training produces a number of graphics for an instructor. Dubbed HuMans, it was designed to help an instructor understand a pilot's cognitive state.

Such tools may help in critical flight phases, suggests Vincent Gilles, vice president of the SNPL France Alpa airline pilots union. "During approach and landing, the transition between instrument flight and the exclusive use of external visual cues is key," he says.

If eye-tracking proves useful in training, what may be next? In Europe, beginning in 2022, the automotive industry will have to integrate systems to detect drowsiness and distraction in every new car. This may contribute to a cultural change when it comes to monitoring a driver and thereby open the door to inflight pilot monitoring.

Inflight encephalography measures the workload in a pilot brain's and displays active areas.

ISAE SUPAERO/INTHEON

Research on Brain Activity To Help Cockpit Design

> BRAIN "CONNECTION" LINKED TO EFFECTIVE COOPERATION

> FUTURE FLIGHT DECKS MAY INCLUDE AI AND ATTENTION MONITORING

Thierry Dubois Toulouse

Flight crews are not always on the same wavelength, but advances in artificial intelligence (AI) may help solve that gap and also improve human-machine interaction.

The phrase "being on the same wavelength" traces its roots to radio communications. It is even more meaningful than it seems. The brains of two people who cooperate effectively have brain waves in key areas running on the same frequency band, recent research work shows.

Such progress in neuroscience, applied to human factors in aviation, opens up possibilities for improving crew coordination. It may help make relevant use of AI. In parallel, nonintrusive monitoring of a pilot's brain during flight may help them better perceive their own workload.

The neuroergonomics and human factors department of ISAE Supaero, the French national higher institute of aeronautics and space engineering division, has been working on how to determine whether two people are coordinating well.

The framework is France's Man Machine Teaming (MMT) defense research program. In an experiment, two people play the role of a fighter pilot and a joint terminal attack controller. They must communicate to accomplish different tasks in a common goal.

Electroencephalography (EEG) shows "connected" brain areas when cooperation is successful. At the same time, heartbeats partly synchronize, says Frederic Dehais, head of the department. Whether the apparent brain and heart connections are a cause or a consequence of good cooperation has yet to be ascertained.

The experiment has also been used to study human-AI cooperation. The human operator was not told when AI was replacing the other participating human. The test proved it is best if both AI and the human operator strictly use the agreed-on phraseology.

Analysis is ongoing, but an outcome may be to design a communications system that switches to AI if it notices poor cooperation.

Dehais' team is upgrading its flight simulator to enable similar observation of a commercial crew. In that environment, resorting to AI would be offered as an option or automated, depending on the pilots' mental state (such as overloaded) and level of cooperation.

During a flight on a single-engine Socata TB20, Aviation Week tested pilot brain monitoring. A headset is equipped with electrodes for a live EEG. The pilot hears regular bass and treble beeps throughout the flight and is requested to mentally count the treble ones. The point in gathering electrophysiological parameters is to correlate them with flight phases and, more precisely, the flightpath.

During the taxi phase, for a person without regular practice, counting is still doable. But as soon as the workload increases, such as during takeoff and turns, it is not. Conversely, the test flight instructor's workload is so low that, as he demonstrates the aerodynamics of a flat turn, he notices the pilot's glance at a "low fuel" light (a benign artifact).

An encephalogram confirms an impression of overload.

After the flight, the pilot is unable to evaluate its duration. The brain had categorized measuring time, as counting beeps, as irrelevant.

The beeps the pilot is supposed to count serve as a probe, says Dehais. They elicit different brain responses depending on workload. Dehais is looking for another stimulus that could be unconscious but that would trigger a cerebral response. The pilot would no longer have to count, but workload would still be measured.

Experiments have shown the brain processes some information even if we are not aware of perceiving it. The brain processes every stimulus but keeps only those relevant for the task at hand, says Dehais. If a stimulus does not even elicit an unconscious response, it means the brain is really too busy, says Dehais.

He sees his work as eventually finding a way to prevent the onset of at-

tention tunneling. "Humans have the capability to deal with complexity, but the brain selects among pieces of information," he says.

To prevent tunneling, the pilot's visual pattern may be followed. If it fails to meet predefined expectations, a system may request the pilot to take a deep breath and check situational awareness, Dehais suggests.

Or the pilot may be trained to reach a high level of concentration. That level may be displayed on a light, the color of which would vary with brain waves. The pilot could thus monitor his or her own mental state.

Many aspects of brain function remain intriguing. The origin of attention tunneling, for example, might be found in prey-predator behaviors, Dehais suggests. But then the way the brain uses energy is paradoxical. In an attention tunneling situation, the brain inhibits some of its own activity. Such active inhibition has a cost, Dehais says.

FREDERIC DEHAIS/ISAE-SUPAERO

France Bureau Chief Thierry Dubois experienced live electroencephalography while flying a Socata TB20 light single to measure the workload in a pilot brain's during various phases of flight.

Some other mechanisms are better known, such as why changing habits is difficult. "Learning and automating decisions is a long process, and then they are engraved; finding a new strategy is costly," says Dehais. This is why crews too rarely perform a go-around when facing difficulties in approach. "The brain's perspective is that landing works every time, while a go-around is a series of actions it seldom performs."

BUSINESS

The New Trend in Acquisitions: Mergers of Equal But Different

> SUPPLIERS WOODWARD, HEXCEL PROPOSE MERGER OF EQUALS

> MAJOR SUPPLIERS, SPECIALISTS SEEK SAFETY IN SIZE AND DIVERSITY

Michael Bruno Washington

Woodward, Hexcel, United Technologies, Raytheon, L3 Technologies and Harris at first glance have relatively little in common except that they are mostly midsize suppliers and specialists primarily serving the aerospace and defense (A&D) market.

Increasingly, that is exactly why they are pairing up—and if other recent deals are an indication, it could be one of the leading trends this year in A&D mergers and acquisitions (M&A).

On Jan. 12, aircraft motion-control specialist Woodward and composites leader Hexcel proposed a stock merger that would create one of the largest independent A&D suppliers, with capabilities spanning wing and engine parts to advanced materials used to make aircraft construction lighter. The companies have minimal sales overlap, which could help ease approval by antitrust regulators.

The combined company, Woodward Hexcel, would hold key supplier positions on most major A&D programs, including: the Airbus A220, A320neo, A330neo and A350; the Boeing 737 MAX, 777X, 787 and Apache helicopter; Bombardier Global 7500; Embraer E-Jets E2; Gulfstream G500/600; and Lockheed Martin F-35 and CH-53.

Perhaps more important for shareholders, the "merger of equals" between Woodward and Hexcel could increase shareholder value. According to the companies, their combined revenue of $5.3 billion would place a merged Woodward Hexcel sixth among major A&D suppliers (see chart). What is more, the combined company, which will be based in Fort Collins, Colorado, should generate about $1 billion in free cash flow—the proceeds from which could boost shareholder returns in its first year. Around $1.5 billion is expected to be sent to shareholders within 18 months of the deal's completion, which is expected to close in the third quarter of 2020.

Initially, financial analysts who cover publicly traded A&D companies were surprised by the proposed combination. But tie-ups that see midsize specialists combining to provide greater portions of A&D systems and parts may well become more commonplace. Last summer, L3 Technologies and Harris paired to form L3Harris Technologies. By summer 2020, United Technologies and Raytheon are expected to close their own "merger of equals" to become Raytheon Technologies.

"I think this deal is very similar to several other aerospace deals that we've seen the last three, four years," Credit Suisse analyst Rob Spingarn says of Woodward Hexcel. "Right off the bat, it looks a lot like Harris and L3. If you line up the PowerPoint presentations from the two deals, they are almost mirror images of each other."

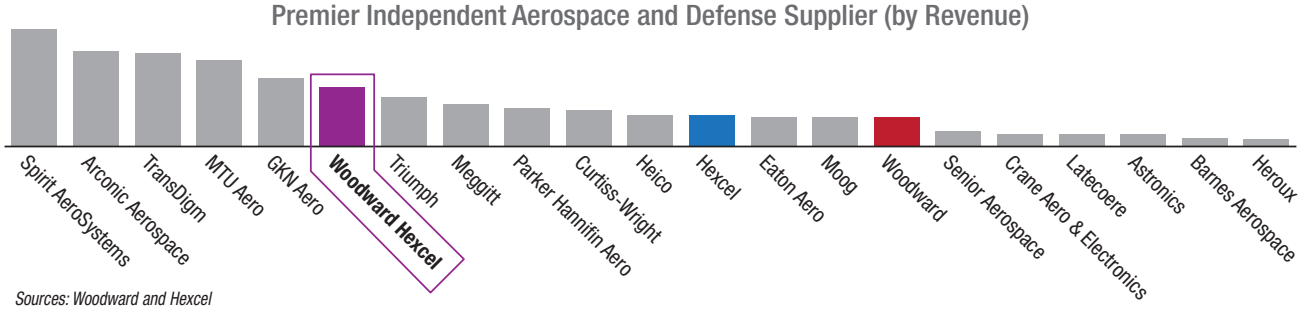
To that end, all of these companies have talked about increasing the amount they spend on research and development (R&D). However, the so-called synergies from the combination of Raytheon Technologies are years off—assuming they occur at all—while rewards for shareholders will be almost immediate.

The CEOs of Woodward and Hexcel assert they will spend $250 million on R&D in the first full year after the deal closes, which according to analysts, is roughly in line with what they were going to spend separately. At the same time, the combined company expects to cut at least $125 million worth of recurring and redundant costs.

Of course, each deal has its own criteria for justification: United Technologies looked to gain heft to fight off Airbus and Boeing supply-chain

How 1+1 Makes Sixth With Woodward and Hexcel

Premier Independent Aerospace and Defense Supplier (by Revenue)



Sources: Woodward and Hexcel

squeezes; Raytheon needed deeper pockets to fund defense technology plays; and L3 and Harris each wanted to become defense primes. Last but not least, Woodward and Hexcel CEOs say they see genuine opportunities to help commercial aviation become more sustainable through the lighter, more efficient design of aircraft and engines.

A&D M&A consultants are preparing to release their year-end summaries for 2019, but dealmakers already are telling Aviation Week they expect a robust environment for M&A deals in 2020, although not universally across the industry.

For instance, subtier commercial aviation suppliers like "mom and pop shops" will continue to be gobbled up, especially by private equity (PE) investors directly or through holding companies as they seek to form new middleweight suppliers. Defense technology specialists also remain hot targets, as evidenced by the mid-December announcement that government services heavyweight Leidos is buying boutique aircraft and defense systems provider Dynetics for $1.65 billion.

But consolidation in space may take top billing among the bevy of startups funded by the venture capital surge of recent years, with major assets such as Maxar Technologies' MDA subsidiary being sold to PE investors at the end of December.

Space-sector combinations could be another major trend for 2020, according to Matt O'Connell, managing partner at Seraphim Capital—the firm that funded the buildup of GeoEye, now a core part of Maxar after MDA. "I think there are a lot of deals out there, waiting to be done," he says.

Moon Rocket Core Stage Ships Out for Testing

Irene Klotz New Orleans

When the administration of U.S. President Donald Trump decided last year to speed up NASA's human lunar exploration blueprint by four years, it immediately hit a formidable obstacle: The first Space Launch System (SLS) core stage, earmarked for an uncrewed mid-2020 flight test around the Moon, was not expected to be finished until August 2020.

To save time, NASA considered skipping a green-run test-firing of the core's four shuttle-era Aerojet Rocketdyne RS-25 engines at the Stennis Space Center in Mississippi. The agency mulled other launch-vehicle options to the long-delayed and overbudget SLS. Ultimately, NASA challenged prime contractor Boeing to come up with a plan to complete assembly of the first core stage by the end of 2019.

With a final push over the holidays, the 212-ft.-long (65-m), 27.6-ft.-dia. vehicle rolled out Jan. 8 from NASA's Michoud Assembly Facility in eastern New Orleans and was loaded onto NASA's refurbished Pegasus barge for shipment to Stennis Space Center in Bay St. Louis, Mississippi.

Pulled by two tugboats, the barge departed at 2:40 a.m. on Jan. 12 and reached Stennis 14 hr. later, setting the

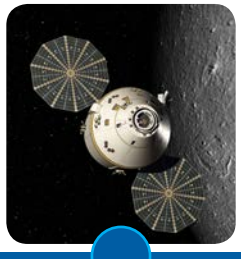
NASA Human Spaceflight Plans, 2005-20

2005

NASA begins work on the Constellation human spaceflight program, aiming to return humans to the Moon and send a crew to Mars. Included development of Ares 1 launch vehicle and Orion Crew Exploration Vehicle.

Facing acquisition and funding issues, the Obama administration cancels Constellation in February.

2010

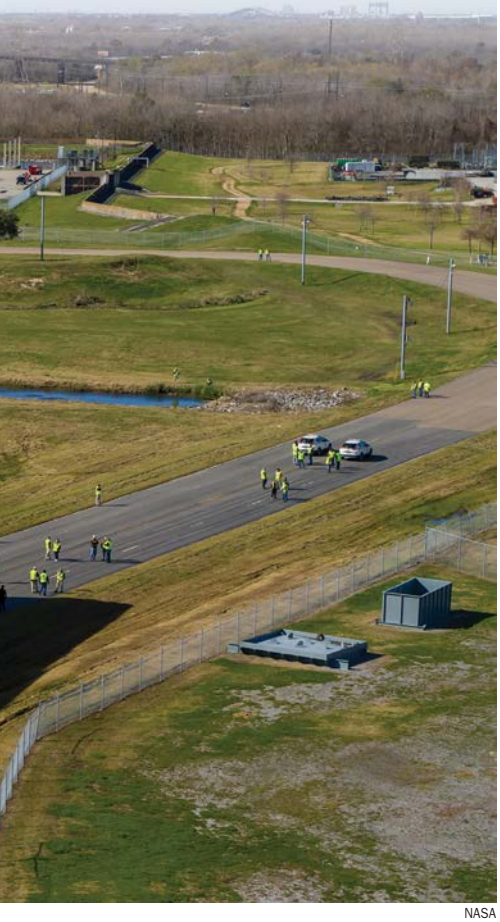


NASA adapts requirements for the Constellation launch vehicle and crew capsule, continuing development through the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle programs.

2011-12

Sources: GAO analysis of NASA documents and prior GAO reports. NASA photos.

The 212-ft.-long Space Launch System core stage heads out from an assembly hangar at NASA's Michoud Assembly Facility in east New Orleans on Jan. 8, heading to the waiting Pegasus barge for transport to Stennis Space Center in Mississippi.



NASA

stage for a series of integrated propulsion system tests on the B-2 test stand that will take most of the year. If the green run goes as planned, the vehicle should be shipped out to Kennedy Space Center in Florida in late August or September, says John Shannon, Boeing SLS program manager.

"Seven years ago, we had a preliminary design and no real factory, and here she is," Jim Chilton, senior vice president of Boeing's Space and Launch division, told several hundred employees gathered at the Michoud plant to watch the core stage depart.

"This is not a trivial accomplishment. In the last year and a half, the NASA-Boeing team invented how to build one of these things," Chilton added, noting that the SLS core stage is roughly equivalent to the instrument unit and two stages of a Saturn V rocket NASA built more than 50 years ago to send astronauts to the Moon under the Apollo program.

"Nothing this complicated has ever come out of this factory," says Shannon, a former NASA flight director and space shuttle program manager. The Boeing team, he adds, comprising 400 engineers and 250 technicians, "has built a new capability for the nation that is going to be used over and over again."

Or not. Following the cancellation of the predecessor Constellation lunar initiative under the administration of former U.S. President Barack Obama, NASA kicked off the SLS program in 2011. But in the years since, the launch services industry has transformed, with private companies, including SpaceX and Blue Origin, bankrolling development of superheavy-lift, human-class, deep-space transportation systems. NASA is counting on private industry partnerships to develop lunar landing systems in time to support a targeted 2024 crewed mission to the Moon's south pole. For now, the SLS, with an initial lift capacity of 77 tons to low Earth orbit (or roughly 57,000 lb. to trans-lunar injection) is the quickest route to get there.

SLS development—accounting for more than $10 billion in costs to date—has been largely paced by the core stage, which is powered by four refurbished liquid-hydrogen- and liquid-oxygen-fed RS-25 engines previously used for multiple space shuttle missions.

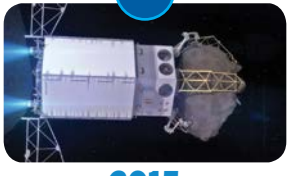
Boeing grappled with technical issues up until the night before the core stage rollout. The last problem to crop up was how to attach a protective cover onto the vehicle's forward section, as winds were too high to do the work outside as planned. In a flight configuration, the core stage forward skirt will be beneath the upper stage and covered by an adapter.

A small team came up with the idea to flip the vehicle, which had been backed into Michoud's Building 110, so that the forward section was inside the high bay. The cover could then be installed inside the hangar, bypassing weather issues.

The final "pucker moment," Shannon says, came as technicians attempted to

2015

Under the Journey to Mars campaign, NASA develops capabilities to send astronauts to Mars. The plan includes the Asteroid Redirect Mission, which entailed sending astronauts to an asteroid boulder that NASA would have placed in lunar orbit to test technologies for deep-space missions. The program was canceled in 2017.



2017

President Donald Trump signs Space Policy Directive 1 in December, calling for the U.S. to lead the return of humans to the Moon for long-term exploration and utilization, followed by missions to Mars and other destinations. NASA establishes the goal of landing astronauts on the Moon by 2028.

2019

In March, the White House directs NASA to accelerate the timeline to land humans on the Moon in 2024. NASA in May requests an additional $1.6 billion in fiscal 2020 to speed up the timeline. It receives $600 million.

2020

First SLS core stage reaches Stennis Space Center in January for green-run test, culminating in a mid-year static firing of the core's four RS-25 engines.


NASA

The first SLS core stage will be put through a series of tests at NASA's Stennis Space Center, culminating in a full-duration static test fire expected in June.

attach the cover, since the practice run on the core stage pathfinder, which was slightly out of round, was not successful. "Once we got that forward cover on, I knew we could make it," he says.

Boeing's real breakthrough came in early 2019, when, faced with an unacceptable eight-month delay, a small team came up with a plan to assemble the stage horizontally, rather than vertically. That enabled parallel operations so assembly was not dependent on completion of the complicated engine section at the base of the vehicle.

"That was a big thing," Shannon tells Aviation Week. "People thought we were going to build a rocket one way for about five years, and they were really wedded to the idea.

"When we first went out and said, 'We think we have a better way to do this' . . . I got told a couple times that it was a harebrained scheme," he says.

In March, after Vice President Mike Pence, who chairs the National Space Council, called on NASA to speed up its planned 2028 Moon landing to 2024, Boeing "really got the message that we had to do something completely different," Shannon adds.

The same team that hatched the horizontal work plan handled final vehicle assembly and integration. "The mindset that we were going to make the end of the year just permeated the whole team," Shannon says.

In hindsight, Boeing and NASA sorely underestimated the time and technical complexity of building the SLS core, particularly since the first build of the vehicle—which comprises a forward skirt, liquid oxygen tank, intertank, liquid hydrogen tank and engine section—served as both manufacturing prototype and flight hardware.

"We're actually building the system to build a lot of these core stages, and we're putting the system together in parallel with building the first one," says NASA SLS Program Manager John Honeycutt. "That's not normally the way you do things. We had a flat budget; we didn't have this big development spike, so we worked really, really hard to be as efficient as we could."

Also contributing to the problems was a perspective that since Boeing had built the International Space Station and currently builds airplanes, it should be able to build a rocket as well, Honeycutt adds.

"We basically just had an empty factory for them, and I think there was a mindset that they have a facility, they have a design. Why can't they just build a rocket? We were seeing schedule improvement along the way, and if you look back over the last 12-18 months, Boeing did a pretty dang good job holding schedule," Honeycutt says.

With the first core stage at Stennis for testing, Boeing is focusing on building the second core, which is earmarked for the Artemis-2 mission, a crewed lunar flight test targeted for 2022-23. Rollout from Michoud is expected in March 2022, and no green run is planned.

SpaceX Nails Crew Dragon Launch Escape System Test

> DRAGON FLIES OFF SIMULATED FAILED BOOSTER

> STARLINER TIMER ANOMALY UNDER INVESTIGATION

Irene Klotz Cape Canaveral

A SpaceX Falcon 9 rocket shut down midair as its payload, a Crew Dragon capsule, rocketed off the booster for a test of its launch escape system on Jan. 18.

A fireball in the skies over Cape Canaveral is not typically a marker of a good day. But when a SpaceX Falcon 9 shut down 85 sec. after liftoff on Jan. 18 any tension in Firing Room 4 at NASA's Kennedy Space Center was immediately eased by the sight of a small capsule soaring up and away from the ominous clouds triggered by the booster's breakup over the Atlantic Ocean.

The rocket actually did not fail. Rather, its nine Merlin engines shut down as planned to simulate a launch abort, allowing it to tumble in the supersonic airstream, where it was ripped apart. Meanwhile, at the moment of engine cutoff the Crew Dragon capsule perched on the rocket's nose fired up its eight Super Draco engines for an 8-sec. burn, accelerating the spacecraft from 1,200 mph (536 m/sec.) to 1,500 mph in approximately 7 sec.

No one was aboard Dragon for the Inflight Abort Test (IFA), the last major milestone before SpaceX launches veteran NASA astronauts Robert Behnken and Douglas Hurley for a trial run to the International Space Station (ISS).

But it would not have been a bad ride had crew flown Dragon's escape system, which generated a combined 64,000 lb. of thrust, subjecting a pair of anthropomorphic test articles inside the capsule to 3.3 times the normal force of gravity.

Two min. and 25 sec. after launch, Dragon coasted to a peak altitude of 131,000 ft., jettisoned its unpressurized trunk section and fired up its smaller Draco thrusters to reorient itself so that its heat shield was positioned in the direction of travel for atmospheric reentry.

Two min. later, at an altitude of about 20,000 ft., Dragon jettisoned a panel near its nosecone, allowing mortars to fire to deploy a pair of drogue parachutes. Four 116-ft.-dia., orange-and-white main parachutes shot out 1 min. later and unfurled to slow Dragon's descent to 20-25 ft./sec.

Dragon splashed down about 26 mi. east of Kennedy Space Center at 10:38 a.m. EST, ending an 8-min. 54-sec. flight test. "There's a lot left to do . . . but by all accounts this was a very successful test," NASA Administrator Jim Bridenstine told reporters after launch.

"It went as well as one can possibly expect," added Elon Musk, the chief engineer, CEO and founder of SpaceX. "I'm super fired-up. This is great."

In addition to a thorough analysis of the flight-test data, NASA wants two more parachute system tests before it will clear Behnken and Hurley to fly on another Crew Dragon to the ISS, a mission known as Demo 2. Launch could take place as early as April.

Demo 1, an unmanned Crew Dragon test flight to the ISS, was successfully completed in March 2019.

NASA also is working with Boeing on its CST-100 Starliner crew transportation system in an effort to restore U.S. human spaceflight services to the ISS, which ended in 2011 with the retirement of the space shuttles.

Both companies have faced technical challenges and lengthy delays. SpaceX, which had planned the IFA for last spring, lost the Crew Dragon capsule earmarked for flight on a test stand while pressurizing the propulsion system for a static test fire.

The Starliner's orbital flight debut in December was marred by a mission-elapsed timer that was set 11 hr. ahead of the actual mission elapsed time, causing the spacecraft to run short of propellant for an engine burn to reach the station. An investigation is underway.

NASA needs both companies' services and has downplayed any competition between the two to be the first to carry crew. For now, Russia operates the only crew ferry flights to the ISS. NASA's last reservation for a seat on a Russian Soyuz capsule is for a flight set to launch in April.

The agency is mulling mission extensions to both Boeing and SpaceX upcoming crew flight tests to help fill the gap in ISS staffing. NASA also is negotiating with Russia for an additional seat should either of its Commercial Crew partners stumble in the home stretch.

SPACEX

Introducing U.S. Space Force

> QUESTIONS REMAIN ON SPACE FORCE UNIFORMS, LOGO, ANTHEM

> SPACE FORCE ROLLOUT OVER THE NEXT 18 MONTHS

Lee Hudson Washington

The U.S. has not established a new armed service in over 70 years. Now it has a Space Force, with a newly sworn-in commander and troops on loan from the Air Force. But before becoming operational, plenty of details must be worked out.

The Space Force received its first member Jan. 14 when Gen. John Raymond was sworn in at the White House by Vice President Mike Pence as the nation's first chief of space operations.

"There are, as you can imagine, thousands and thousands of actions that are going to have to take place—everything from what does a uniform look like to a logo, all the way up to who is in the Space Force and who isn't in the Space Force," Raymond says.

The chief of space operations for the U.S. Space Force displays the new service's uniform name tapes in the Pentagon.

TECH. SGT. ROBERT BARNETT/U.S. AIR FORCE

The Space Force became a reality Dec. 20 when President Donald Trump signed the Fiscal 2020 National Defense Authorization Act (NDAA) into law. With a swipe of a pen, over 16,000 active duty and civilian personnel from Air Force Space Command were assigned to the Space Force. Although the 16,000 personnel are "assigned" to the Space Force, they are not technically "transferred" to the new service. That formal step can only occur for officers through a new appointment or by being enlisted into the new service. The Department of the Air Force will provide information to personnel to guide their decision.

The new law has the headquarters and units fold into the Space Force immediately. A legislative proposal the Pentagon sent to Congress on creating a Space Force says the military needs 60-90 days to assemble the initial staff and one year to bring in units.

Over the last nine months, the Pentagon had a planning team figuring out the next steps for establishing a new service, and the Defense Department intends to roll out the Space Force over the next 18 months. "We're not going to be in a rush to get something and not do that right," Raymond says. "This is not a farce. This is nationally critical."

In the near term, there may be announcements about renaming Air Force bases as Space bases for installations that focus on space to better align with the nascent service. Raymond gave Vandenberg in California and Buckley (in Colorado) AFBs as examples. "I just want to point out, though, that we will rely very heavily on the Air Force to operate those bases, but will work to rename those to match the mission," Raymond says. Air Force Secretary Barbara Barrett is still assessing where U.S. Space Command's headquarters will reside; options include Alabama, California and Colorado.

Creating a Space Force is seen by some inside the Pentagon as a tool to improve recruiting and retention of space personnel. There is even buzz from Hollywood about Steve Carell and Greg Daniels creating a web-based television series for Netflix called "Space Force," which is expected to come out this year.

Historically, most space jobs were in support of the government. But now the military is competing for talent with commercial companies such as Blue Origin and SpaceX. The Space Force is trying to ride the wave of interest by hiring civilian personnel with general service-15 salaries in Washington starting at $142,701.

Both Army and Navy personnel have participated in Space Force planning, and the National Guard and Reserve have also expressed interest, Barrett says. However, the Fiscal 2020 NDAA does not assign personnel from the other services, only from the Air Force.

Army Secretary Ryan McCarthy recently met with Raymond and other officials for 2 hr. to discuss the Space Force's standup. Among the topics: "What are the things that need to stay organic to the Army," McCarthy says. "Helicopters are in the Army and the Air Force. Are there organic space capabilities that need to stay in the Army, and what do you have to divest to the Space Force?"

He declined to specify what capabilities he would like to see remain in the Army.

The Space Force will not be measured by the number of people that make up its force structure because it is not labor-intensive like the other military services. Instead, it is measured by technology and capabilities. For example, 40 operators control the entire GPS system, and roughly a half-dozen personnel are on shift at one time, Barrett says.

"It's a different sort of portfolio than what we might be thinking of when we generally think about warfighting regimes," Barrett says.

Gen. John Raymond

Few members of the U.S. military have focused their career on space, but Gen. John Raymond is one of them. He commanded the 5th Space Surveillance Sqdn. in the UK, led the 30th Operations Group at Vandenberg AFB, California, the 21st Space Wing at Peterson AFB, Colorado, and the 14th Air Force and the Joint Force Space Component Command. The 14th Air Force was transferred in December by Air Force Secretary Barbara Barrett to the Space Force and is now known as the Space Operations Center. In 2015-16 Raymond served as a space-focused deputy chief of staff operations at the Pentagon, followed by leading the Air Force Space Command and U.S. Space Command (Spacecom). Raymond is now serving a dual-hatted role as the chief of space operations and the head of Spacecom.

U.S. AIR FORCE

Gen. John Raymond during his swearing-in ceremony at the White House as the nation's first chief of space operations.

Raymond in his role as chief of space operations will report directly to Barrett and is mandated by law to become a member of the Joint Chiefs of Staff after one year. Lawmakers agreed to have an assistant secretary of defense for space policy as the senior civilian in the Office of the Secretary of Defense conducting space warfighting oversight.

Congress will continue to use the power of the purse to conduct strict oversight of the new service. The fiscal 2020 defense appropriations bill directs Barrett to submit a monthly "spend plan" for the Space Force. "The spend plan shall include, but not be limited to, funding for civilian personnel (including the number of full-time equivalents), supplies and materials, and contract support," the explanatory statement accompanying the bill says. "If there is a change to the spend plan in any given quarter, the Secretary of the Air Force shall provide written notification to the congressional defense committees not later than 10 business days following the end of that quarter explaining any adjustments."

Asked whether the Pentagon had considered launching a contest where service members could submit ideas for the Space Force's anthem, Pentagon spokesman Jonathan Hoffman said during a briefing: "That entire idea makes me uncomfortable. I will check with Gen. Raymond the next time I see him on anthem plans."

TRUMP'S INFLUENCE

Trump's interest in creating the Space Force reenergized the movement and convinced skeptics in the Senate, according to House Armed Services Committee Reps. Jim Cooper (D-Tenn.) and Mike Rogers (R-Ala.). Discussion on creating a Space Force began five years ago, beginning with Cooper and Rogers. Much of the information that convinced the two lawmakers of the need for a separate military service focused on space is classified. But the military is beginning to see the importance of declassifying some space threat information. Barrett acknowledges that most Americans do not realize how large an impact space has on their daily lives.

One concern the Senate had was that the House was trying to force too much change at once. Altering the plan by establishing a Space Force in a gradual process put senators more at ease, Rogers says.

A Senate-confirmed assistant secretary of the Air Force for space acquisition and integration is to serve as the Pentagon's senior space architect. This individual will chair the Space Force Acquisition Council and oversee and direct the Space and Missile Systems Center, Space Rapid Capabilities Office and Space Development Agency (SDA). The position will take on service acquisition executive responsibilities for space systems and programs beginning Oct. 1, 2022.

The SDA is preparing to be absorbed by the Space Force at that time instead of residing within the Office of the Secretary of Defense. The nascent agency released a short-term acquisition strategy that includes launching a multilayer small satellite constellation beginning in fiscal 2022. It is yet to be seen once the SDA is folded into the Space Force if it will cease to exist or continue along the established path.

The short-term acquisition strategy is to accept bids from companies that can offer technologies ready for launch within 18-24 months and at a price point of tens of millions of dollars as opposed to exquisite satellites traditionally purchased by the Air Force with a hefty price tag.

Allowing the Space Force to take control of the SDA is a concession the House made during conference. "The Senate wanted that, and they get a say-so on this too, whether we like it or not," Rogers says.

The greatest resistance to creating a Space Force came from the Air Force, because the service wanted to continue using the space budget as a piggybank to fund air dominance programs, Rogers says.

"There was political pressure to not birth this baby," Rogers says. "People tried to kill this baby in the womb for the last three years. I believe there's going to be some people who want to see it die in the crib over the next few years. We're not going to let that happen."

Data-Link Mandates Come Due

> NORTH ATLANTIC DATA-LINK MANDATE IS EXPANDED

> EUROPEAN DATA-LINK SERVICES RULE TAKES EFFECT

> BUSINESS AIRCRAFT EXEMPTED FOR EUROPE'S RULE

Bill Carey Washington

Separate mandates requiring aircraft to be fitted with data-link avionics when operating over Europe and in the North Atlantic airspace have come due.

Phase 2C of the North Atlantic Data Link Mandate requires that by Jan. 30 aircraft flying between 29,000 and 41,000 ft. be capable of interacting with air traffic control through the use of satellite-routed controller-pilot data-link communications (CPDLC) and periodically reporting their position by automatic dependent surveillance-contract (ADS-C).

Exceptions are made for airspace north of 80 deg. N., the New York Oceanic East flight information region, certain "Tango" routes and airspace where surveillance is maintained by radar and/or automatic dependent surveillance-broadcast (ADS-B) coupled with very-high-frequency (VHF) radio.

The mandate has been implemented in phases since 2013, when aircraft flying at 36,000-39,000 ft. along two specified tracks within the North Atlantic Organized Track System required avionics for CPDLC and ADS-C, components of the Future Air Navigation System 1/A (FANS 1/A) construct developed by Boeing and Airbus in the 1990s.

The objective of the North Atlantic Systems Planning Group, an International Civil Aviation Organization regional planning entity, is that 95% of aircraft operating at or above 29,000 ft. in North Atlantic airspace be equipped with FANS 1/A by this year.

Europe's Data Link Services (DLS) mandate requiring that aircraft flying above 28,500 ft. be CPDLC-capable takes effect on Feb. 5. The European regulation specifies the Aeronautical Telecommunications Network B1 (ATNB1) message protocol, which differs from the FANS 1/A message set used by the U.S. Data Comm program. Both are transmitted over land by VHF Data Link Mode 2 (VDL2) radio.

FANS-equipped aircraft are exempt from the DLS mandate, and some air navigation service providers (ANSP) such as Eurocontrol's Maastricht Upper Area Control Center (MUAC) will continue providing data-link service to FANS aircraft. European and FAA plans call for transitioning to an ATN Baseline 2 communications protocol over VDL2 around 2030 to harmonize U.S. and European requirements.

The original DLS implementation regulation the European Commission (EC) issued in 2009 called for aircraft to be equipped by February 2015. But that year, compliance dates for the ground infrastructure and aircraft were postponed to 2018 and 2020, respectively, due to technical problems.

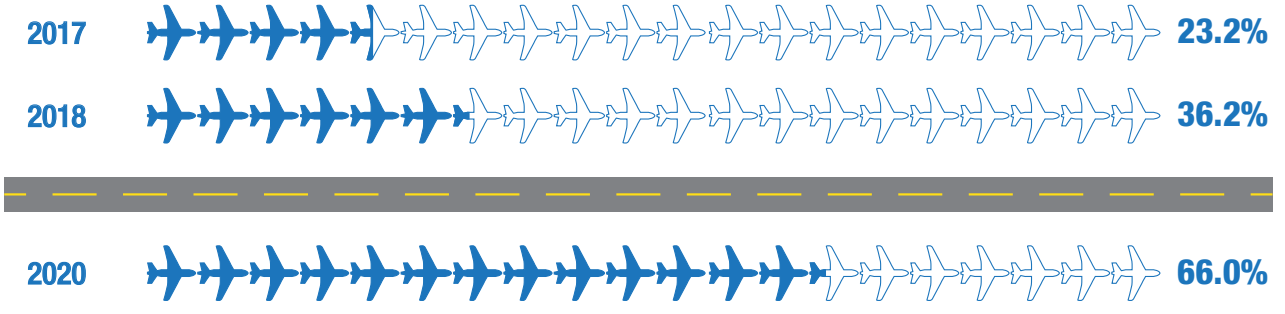
The EC approved the changes after a European Union Aviation Safety Agency investigation revealed a systemic issue of data-link disconnections called "provider aborts" (PA). The MUAC had reported an abnormal number of PAs in 2008. Similarly, other ANSPs and aircraft operators were experiencing technical issues, particularly involving disconnections.

Last July, the EC amended the DLS regulation further to exempt aircraft certificated before January 1995; aircraft certificated before December 2003 that will cease operating by Dec. 31, 2022; aircraft fitted with data-link equipment prior to 2018; and aircraft with a seating capacity of 19 passengers and a maximum takeoff weight of less than 100,000 lb. (45,359 kg).

"Acknowledging the issues and corrective actions taken and recognizing the objective that at least 75% of the flights should be equipped with data link capability, the criteria for exemptions should be amended," the EC states.

"Those criteria should remain effective, without placing an undue economic burden on specific operator categories which contribute significantly less to the overall number of flights," the amendment adds. "Such

ATN B1 Message Protocol Capability in Multifrequency Environment



Source: Sesar Deployment Manager

The Sesar Deployment Manager estimates 66% of aircraft in Europe will be equipped with ATN B1 data-link capability this year.

categories should include operators of aircraft with FANS 1/A systems installed, operators of older aircraft and of aircraft designed to carry 19 passengers or less."

The amendment effectively excuses most business and general aviation aircraft from the regulation, with the exception of very-large-cabin business jets such as the Gulfstream G650ER and airliner variants produced by Boeing Business Jets and Airbus Corporate Jets, notes the National Business Aviation Association.

Last November, the EC permanently exempted certain older aircraft types and early versions including Airbus A300s, A330s and A340s; Boeing 737s, 747s, 757s and 767s; Fokker 70s and 100s, and all Ilyushin Il-76s. "The exemptions should maintain the objective . . . that at least 75% of flights should be equipped with data link capability," the commission says.

In a report dated Dec. 19, the Single European Sky ATM Research Deployment Manager (Sesar DM), a Brussels-based agency that oversees

COLLINS AEROSPACE

A Collins IDC-900 integrated data-link controller displays CPDLC messages.

implementation of Sesar programs, said CPDLC usage on the continent has grown from just over 0 hr. in January 2013 to a total of 40,000 hr. last July. This has been coupled with a "massive performance improvement" in PAs.

"Starting the analysis from the middle of 2016, it is visible that the CPDLC usage has grown around five times until today. While at the same time the PA rate decreased with a factor of 7," the agency writes in its report. But further investments will be needed to reach the goal of one PA per 100 hr. of CPDLC usage, the authors add.

As of a monitoring exercise it conducted last May, the Sesar DM found that the ANSPs of 18 countries provided DLS in compliance with the regulation. Five other countries provided service but were not fully compliant, and seven—Cyprus, Greece, Lithuania, Malta, Norway, Romania and Slovakia—were not providing service.

The Sesar DM estimates 66% of more than 18,000 aircraft in Europe will be ATN-B1-capable this year. The agency expects to release updated information on operators' compliance with the mandate by April.

ALPINE CHALLE

- KOPTER CLOSE TO FINALIZING CONFIGURATION OF SH09
- SINGLE-ENGINE IFR CAPABILITY PLANNED FOR 2022
- CLOSE RELATIONSHIP ESTABLISHED WITH KAI IN SOUTH KOREA

Tony Osborne Pozzallo, Sicily

Switzerland's Kopter Group believes it can shake up the light-single-engine rotorcraft market with its SH09 helicopter.

As a newcomer in an industry with tall barriers to entry, the fledgling company is making major strides in flight-testing progress as it aims to bring its distinctive helicopter to market in 2020.

"The market is big," says Kopter CEO Andreas Lowenstein, "and bigger than what the forecasters are saying."

Lowenstein, a former Eurocopter executive, says the rotorcraft market is an "offer-driven market . . . if you come up with the right product at the right cost, safety, payload and economic performance, and if the equation is right, you can resize the market."

He points to the Leonardo AW139 twin-engine medium rotorcraft as an example, which entered a market previously dominated by Airbus AS365/EC155 Dauphins, Sikorsky S-76s and Bell 412s.

"When the AW139 arrived, it was a real game changer," he says. "Suddenly, the market was 1.5-2.5 times bigger than in the past. I feel if we can do it right, we can provoke the same effect."

The vision is not too farfetched, as the SH09 is entering a market that has been arguably starved of innovation for decades. Airbus' H125 Ecureuil, or AStar as it is known to the U.S. market, is the reference point for the SH09, as is Bell's 407.

The 407 is a more powerful derivative of Bell's 1960s-era LongRanger, while the H125 was born from Aerospatiale's AS350, which first flew in the 1970s. Both have undergone iterative upgrades over the years, receiving uprated engines and new avionics.

The Honeywell HTS900-powered SH09 already appears to have secured some market share, with 70 firm orders and more being saved up for announcement at Heli-Expo. Lowenstein says the company has "solidly sold" the first three years of production output, with some customers now ordering for the fourth and fifth years.

"People are waiting for this aircraft, and we are seeing bigger operators in the EMS [emergency medical services] and tourism, being extremely interested," says Lowenstein.

He also notes that the customers who previously would have been in the market for a twin-engine helicopter in the class of Airbus' H135 and the Bell 429 are looking at the SH09 because of the improved economics associated with a single engine.

Kopter already has secured a site for future final assembly in the U.S., at Lafayette, Louisiana, beginning in 2025 and has made some inroads into the Asia-Pacific market (*AW&ST* March 11-24, 2019, p. 40).

In October, the company signed a framework agreement with Korea Aerospace Industries (KAI) for marketing, sales and potential assembly of the helicopter in South Korea.

Lowenstein reports the Koreans are potentially interested in the SH09 as a training platform for the military, which could lead to a "joint industry project to cover Korean needs."

"Today, we have working groups [with KAI] progressing on a program which has a number of phases looking at what markets we can tackle, work on industry and about potential technology transfer," he explains.

Lowenstein says the SH09's hidden benefit has been its size. The helicopter offers a cabin not dissimilar in size to

NGER

TONY OSBORNE/AW&ST

Good visibility makes SH09 attractive for tourism and utility operators.

Kopter SH09
By the Numbers

Weights

Max. takeoff (internal) . . . 2,850 kg /6,284 lb.

Max. takeoff (external) . . 3,000 kg /6,614 lb.

Max. payload (external) . . . 1,500 kg/3,300 lb.

Seating . . . . . 1+8

Engine . . . . . Honeywell HTS 900

Performance

Cruise speed . . . . . 260 kph /140 kt.

Range . . . . . 800 km/430 nm

Endurance . . . . . 5 hr.

Source: Kopter

its twin-engine competitors, capable of seating up to eight passengers with a single pilot. In the rear under the tail boom, large clamshell doors provide access to the rear cabin to load a stretcher or baggage. Loading at the rear can be done with the engines running, thanks to the shrouded Maestro anti-torque system.

Up front, the current prototype, P3, is using a Sagem-developed avionics suite, but production aircraft will use the Garmin G3000H system, which allows the aircraft to be single-engine IFR-ready (instrument flight rules) once development of a four-axis autopilot is complete and certified. The company's road map for this work foresees the SH09 being IFR-ready in 2022. IFR-capable single-engine helicopters are coming back into fashion, in part prompted by the U.S. Navy's need for an IFR-certified training helicopter, but industry is already seeing growing interest from the EMS industry, particularly in the U.S.

Development of the SH09 has taken place in fits and starts since the concept was unveiled in 2011 by the then-Marenco Swisshelicopter. An initial prototype, P1, which flew in 2014 was a "proof of concept," says Michele Riccobono, Kopter's chief technical officer and head of flight operations. P2, which flew in February 2016, took the concept a little further, but it was P3, which took to the air in November 2018, that the company says represents a "reset" in terms of design and development. Both P1 and P2 have been withdrawn.

Testing did not start well, however, when it was discovered through nondestructive testing that the castings of the upper housing of P3's main gearbox had major defects. Engineers noted shrinkage, porosity and even areas that had been repaired by welding with the wrong filler. None of the issues had been reported by the supplier. The gearbox is critical as it also features four load-bearing arms that connect it to the helicopter's airframe.

"If I have to list the important jeopardizing issue for the SH09 development, it is the gearbox. . . . The aftermath cost us close to nine months of delay," says Riccobono.

Although the supplier was fired immediately and a new one found, it would take months before the new components would be ready. The decision was made to fly with a limited flight envelope with the best of the castings, and several of the worst were broken as the company worked to define load limits.

"We had to convince ourselves first that it was safe enough to fly in a limited envelope with the flawed casting," says Riccobono. "Once they saw how we approached it, EASA (the European Union Aviation Safety Agency) gave us the clearance."

The casting was instrumented, and the limitations in the flight envelope were severe. Even during takeoff, the crew could not apply lateral cyclic, so the aircraft had to take off and land sliding sideways.

"With that gearbox, we achieved a lot," says Riccobono. "We reached 11,300-ft. density altitude and a speed of 125 kt., and we were able to fine-tune the aerodynamics."

Retrofitting the gearbox with a revised upper housing provided by the new supplier in September was a "relief" says Kopter's chief test pilot, Russ Grant. "We could finally start flying with the pilots flying the helicopter rather than the helicopter flying the pilots," he adds.

"If we had not spotted the issues, most likely we would have had a serious accident," says Riccobono, pointing out the defective castings could carry only one-third of the expected load.

Internally, the SH09's main gearbox differs from other helicopters, as it uses an architecture in which the planetary stage employs stationary planet gears and a rotating ring that is connected to the main rotor mast. This contrasts with most light helicopters, which use a fixed ring, with the main rotor mast connected to planet gears rotating around a sun gear. Kopter says its patented design makes it easier to lubricate the planetary gears and bearings as one oil-jet nozzle can be provided for each gear. The gearbox is less likely to jam in the event of planet-gear failure.

Since the gearbox retrofit, the flight-test team has been steadily increasing aircraft weight to 2.6 metric tons, moving toward the planned maximum takeoff weight of 2.85 metric tons.

Flight testing is underway in Pozzallo, a small heliport on the southern coast of Sicily. The area is blessed with open unrestricted airspace and much better weather than Kopter's Swiss home, where restrictions mean

flying cannot take place even during lunchtime. During December, the engineering team began testing a new rotor head and main rotor blades with the aim of installing them in January, bringing the aircraft closer to its final production standard configuration.

Test pilots say the aircraft is flying well, with low vibration, a comfortable ride and low pilot workload, but in some corners of the envelope "it shows some weaknesses," says Grant. "It is a case of finessing those corners of the flight envelope."

The company is targeting certification this year under EASA's CS27 standard for small rotorcraft, with Kopter planning to introduce additional capabilities through the notification of the design-change process.

The first certification step will be to have the aircraft approved for visual-flight-rules operations to a density altitude of 16,000 ft. and a temperature operating range of -10 to 35C. The company then plans to extend that temperature range with cold-weather trials in Alaska and then hot-and-high

TONY OSBORNE/AW&ST

The Maestro shrouded tail rotor helps improve safety on the ground, particularly during loading and unloading with the engine running.

flying in Colorado. These trials will be performed by production-standard prototypes PS4 and PS5, with PS4 envisioned to fly later this year.

Other upcoming changes include a new fuel tank configuration. Currently the aircraft uses tanks made of Kevlar, with two fitted under the cabin and one each in the rear cabin walls for a total capacity of 750 liters. However, drop tests revealed the tanks could not sustain the impact, prompting the company to adopt a new configuration developed by Safran's Zodiac. The new configuration uses fuel bags and concertina fuel lines that can cope with the drop-test impact.

The SH09 also will be equipped with a cockpit voice recorder as standard equipment to support post-accident analysis. Such equipment is not standard in this class.

Work is now underway to gear up for production in Switzerland. The company's facilities at Mollis will be big enough for the initial production phase of around 25-30 aircraft per year. Architects are putting finishing touches on plans for a new 24,000-ft.^{2} facility that will join the company's geographically separated facilities under one roof. The aim is to have the facilities ready for 2022, for an envisaged ramp-up in production.

Lowenstein says the company wants to stay under the radar and not attract too much attention from its larger competitors. "There is no reason to excite everybody today . . . but I think it is difficult to do much better than what we are doing, and we are a number of years ahead," he says.

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Formula 1 Technology Inspires British Helicopter Proposal

> HORIZON LOOKS FOR INVESTORS TO TAKE PROJECT TO CONCEPT

> AUTO-COPTER TO BE POWERED BY SMALL ENGINES OR BATTERIES

Tony Osborne London

A team of British engineers and entrepreneurs are proposing the development of a new, largely autonomous rotorcraft for the general aviation air taxi market and urban air mobility mission.

At a time when billions of dollars have been invested in fully electric-powered vertical-takeoff-and-landing (VTOL) aircraft, the team at Horizon is proposing a more conventional single main rotor configuration—but one with a relatively unconventional architecture.

Ron Stewart, Horizon's chief technology officer, who has been working on the concept since 2014, says the Horizon Auto-Copter is envisioned as "disruptive" and "technologically advanced" but also has been designed to be a "simple, cheaper and customer-friendly product."

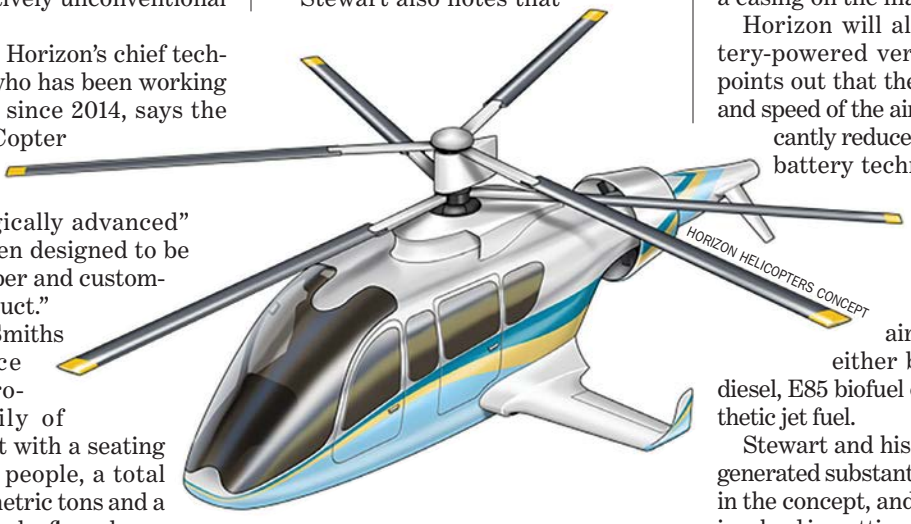
The former Smiths Aerospace vice president is proposing a family of Horizon aircraft with a seating capacity of 2-8 people, a total weight up to 2 metric tons and a design tailored to be flown by customers with a private pilot's license.

Horizon's proposal will be a three-engine electric-hybrid coaxial compound rotorcraft with forward propulsion provided by a ducted fan fitted to the rear.

Rather than flying the aircraft like a helicopter—with cyclic, collective and anti-torque pedals—the Horizon aircraft will use a multichannel fly-by-wire flight control system with the pilot controlling the aircraft through a three-axis joystick for directional control and a propulsor power lever.

Three engines may sound thirsty, but Stewart is not proposing the use of traditional helicopter turboshafts. Instead, micro gas-turbine generators, derived from technology currently seen in the MGU-H (Motor Generator Unit, Heat) component of a Formula 1 racing car will produce the electrical power needed to drive both the main rotor and propulsor fan. Using three engines will give the Horizon machine Category A performance, Stewart says, a capability afforded only to twin- and triple-engine helicopters that allows the aircraft to continue its flight safely in the event of an engine failure. Such a capability should enable the aircraft to perform urban air mobility (UAM) missions, for example, operating from the tops of buildings.

Stewart also notes that a hybrid propulsion system gives the designers more freedom in placing parts of the drive system. The Horizon team is also studying options for both fixed-pitch and variable-pitch propulsor fans, with the variable pitch being looked at for its ability to slow the Auto-Copter down for hover, approach and landing.



Auto-Copters would be offered in different configurations from 2-8 seats, with or without wings and either with a conventional or battery-powered propulsion system.

"It will fly just like a fixed-wing aircraft, flying level rather than nose down like a helicopter," explains Stewart. "By making it easier to fly, almost as easy as [driving] a car, we are opening the market up to a much larger number of consumers." Remote pilotage will facilitate one-way trips and shared ownership.

On routine flights, the pilot would not have a heavy workload, perhaps flying "hands-off" for most of the time, he adds. A flight planning and management system will map out and fly routes avoiding high ground, weather, buildings and prohibited airspace, while sensor-like Lidar will watch out for upcoming obstacles and, if necessary, take avoiding action.

The aircraft would be equipped with a health and usage monitoring system, with the fly-by-wire and haptic flying controls helping to keep the Auto-Copter in a safe flight envelope with low maintenance costs.

A key focus of the team has been on weight reduction, driving the extensive use of carbon fiber in the structure and the fuselage—even as a casing on the main gearbox.

Horizon will also produce a battery-powered version, but Stewart points out that the range, endurance and speed of the aircraft will be significantly reduced, given the current battery technologies. However, emerging battery technologies will alleviate this to some degree. Gas-turbine variants of the aircraft will be fueled either by normal jet fuel, diesel, E85 biofuel or carbon-zero synthetic jet fuel.

Stewart and his team have already generated substantial investor interest in the concept, and they are currently involved in putting together the launch group of investors. The company plans to pursue UK government grants.

Stewart says the cost of bringing the aircraft to market will be "substantial," but he is confident about the returns it will generate. The team has already identified suppliers in the UK and U.S. for major components, all of them medium-size enterprises. Stewart also believes the personal transport variants of the aircraft could be sold, especially to high-net-worth individuals through automobile-like showrooms. "They go looking to buy a Ferrari and end up with a Horizon Auto-Copter," says Stewart. Target price for the Auto-Copter family would start at around $800,000 and climb to around $1.2 million for the larger, professionally flown fare-paying passenger models.

Bell 525 Aces Customer Evaluations as Certification Draws Closer

> FLIGHT TESTING PASSES THE TWO-THIRDS MARK

> FLY-BY-WIRE SOFTWARE QUALIFICATION ON TRACK

Graham Warwick Fort Worth

Bell is entering the final stages of certification testing on the 525 Relentless, buoyed by positive initial feedback from customers. The boost comes as the eighth year of development of the super-medium twin-turbine helicopter draws to a close, with several months of testing still ahead.

Bell is not saying when it expects to certify the 525, but with 1,500 hr. logged, the helicopter is more than two-thirds of the way through its planned flight-test program. FAA certification by the summer is "mathematically defensible," says Josh O'Neil, manager of technology and evaluation.

The 525 is all-new, Bell's largest helicopter yet and the first commercial helicopter with fly-by-wire (FBW) flight controls. It marks a return to a market the company once served with the 214ST. But with a maximum gross weight of 20,500 lb., the 525 is substantially heavier and more capable.

Flight testing has been underway for four years and is supported by four aircraft. Ships 2, 3 and 14 were joined in late 2019 by Ship 15, the first with a production 16-passenger interior designed for offshore operations. The first aircraft was lost in July 2016 in a fatal accident, which delayed the program by more than a year.

While it declines to commit to a date for certification, Bell reports significant progress with testing. By early December, five of eight drive-system qualification tests had been completed, including running the transmission without lubrication for 1 hr. to meet the European Union Aviation Safety Agency's 30-min. run-dry requirement. Drive-system certification testing is expected to be completed in the second quarter.

General Electric has certified the 1,800-shp, digitally controlled CT7-2F1 engine. Suppliers had completed 170 of 190 qualification tests by early December and were on track to complete their work in the first quarter. Development of flight-control and avionics software is "keeping track with certification requirements," says O'Neil, and on schedule for qualification in the second quarter.

In 2019, Ship 2 completed cold-weather testing and control-law tuning. Work to be completed in 2020 includes tests of handling qualities and noise, after which Ship 2 will be used as the ground endurance test vehicle, then retired and modified into a maintenance trainer.

Ship 3 completed load-level surveys including slope landings in 2019. Its next tasks are one-engine inoperative, height/velocity curve and Category A takeoff testing. Ship 3 also will test flight-control failure modes and handling qualities and conduct a search-and-rescue loads survey.

In 2019, Ship 14 completed snow and propulsion testing, including operation in full blowing snow and compatibility testing of the engine and auxiliary power unit. On the to-do test list for 2020 are inlet distortion, propulsion and avionics cooling, flight director and emergency floats.

In addition to the initial customer evaluations by pilots and passengers, Ship 15 has been used for high-intensity radiated-field and low-level lightning tests. Next up are fuel system calibration, fire extinguishing, emergency egress, and electrical and avionics testing.

Production-configuration Ship 15 will be used for FAA function and reliability testing—an extended period of flying on representative missions. After certification, Ship 15 will be Bell's demonstrator.

A close inspection of Ship 15 at Bell's Flight Research Center in nearby Arlington, Texas, underscored the 525's size and highlighted its sophisticated cockpit, capacious interior even in the high-density four-abreast offshore layout, large windows and a high standard of aircraft completion.

Despite the progress, Bell "can't set accurate expectations on certification, but I think we will soon," says O'Neil. Because of its FBW system, certification of the 525 involves a number of industry firsts.

These include a nondepletable emergency power system. This is attached to the main rotor and provides power to the triplex flight-control computers, electrics and hydraulics as long as the rotor is turning, so the systems are not lost if the engines fail.

BELL

Bell 525 Ship 15 will conduct function and reliability testing, the final step before expected FAA certification.

The 525 also has autorotation entry assist, which is unique to FBW and was tested by Ship 2 in 2019. The first second after power failure is the most important, says O'Neil. "For certification, we assume the pilot does not do anything for that first second, then gets on the controls. We lose that second," he says. In the 525, if power fails the FBW immediately begins making inputs to the controls, lowering collective pitch to maintain rotor speed. This will be part of the initial certification, he says.

Despite a flat market, customers are eagerly awaiting the 525, says Bell. Initial pilot evaluations rated the handling qualities as impressive, while passengers praised the smooth ride, describing the seating as a step-change in comfort over current offshore helicopters. It has been a long road, but Bell increasingly is confident the 525 is the right helicopter for the market.

Airbus Boosts Automation Features in the H160

- FIRST H160 DELIVERIES WITH CERTIFICATION ARE IMMINENT
- AIRBUS HAS DEVELOPED A VORTEX-RING-STATE WARNING SYSTEM FOR CREW

Tony Osborne Marseille, France

Airbus is in the final throes of certifying its H160 twin-engine medium rotorcraft, which emerged out of the company's X4 program in 2015. The helicopter is expected to reach its first customer—an undisclosed buyer in the U.S.—during the second half of 2020, followed by deliveries to global launch operator Babcock.

With a maximum takeoff weight of 6,050 kg (13,340 lb.), the Safran Arrano 1A-powered aircraft is aimed for an anticipated wave of orders as operators plan to replace Bell 412s, early-model Leonardo AW139s and Sikorsky S-76s. The H160 also is intended to fit into the product family space held by the H155, whose development is being transferred to Korea Aerospace Industries as the basis for its Light Civil Helicopter and Light Armed Helicopter.

As part of the H160's development, Airbus focused on producing a more automated aircraft and as it approaches market entry, the company has revealed more detail about the capabilities of the latest version of the helicopter's Helionix avionics suite. The internally developed system was introduced on the H225 twin-engine heavy helicopter and since has been included on the H175 as well as the H135 and H145 at the lighter end of the Airbus product range.

"A lot of time has been spent on developing the human-machine interface and reducing the workload of the crew," says Oliver Gensse, chief test pilot for the H160 program.

Helionix has a "complex architecture," he says, yet that complexity is not passed to the pilot. Instead, the system manages activity in the background and only "lets the pilot know if necessary."

Demonstrating the aircraft's systems during a flight in January using the third prototype H160, Gensse showed how the Arrano engines can be started and brought to idle in just 2 min., with the procedure managed by the full-authority digital engine control. An onboard training mode can simulate engine-out conditions even during takeoff.

One focus has been on providing a high level of equipment on the baseline aircraft, notes Gensse. Standard equipment includes a weather radar, traffic-alert and collision-avoidance system (TCAS II), and a helicopter terrain-awareness and warning system.

With the development of a four-axis autopilot, the team has introduced a recovery system that returns the helicopter to stable level flight at the last recorded speed and altitude. Gensse explains the system has been designed for regular use and not just emergency situations, and can be activated with the double-click of a button on the cyclic.

According to Gensse, the recovery button could be used if the pilot becomes disorientated in low visibility or when sudden maneuvers are required to take avoidance action. Even

ERIC RAZ/AIRBUS HELICOPTERS

the shock of a bird strike on a windshield can result in pilot feedback into the controls, which can be recovered using the system. The H175 super-medium platform has a similar system, but he says the version on the H160 is the most advanced.

Gensse and the engineering team are particularly proud of the addition of a vortex-ring-state (VRS) warning system that provides visual and aural alarms when the aircraft is approaching VRS flight conditions.

VRS, also known as settling with power, occurs when the main rotor loses lift, and it often results in a loss of control and high sink rates. Gensse says the VRS warning system predicts flight conditions ahead over a 10-sec. period, initially providing visual warnings on the main multifunction display and then aural alarms in the final seconds. The VRS warning system has not been designed to take corrective action, but instead prompts the pilot to do so.

A U.S. customer will be one of the first to receive an H160 later this year.

Autopilot development also has led to the creation of an automatic takeoff mode, which will set up the helicopter to perform a Category A takeoff, where the aircraft will lift into the hover and climb slowly backward. In this situation, should an engine fail, the helicopter can settle back onto the landing area or depart in stabilized single-engine flight. The autopilot also is designed to fly landing approaches to within a few feet, although the pilot will have to perform the actual landing.

Other areas of focus are on reducing vibration and lowering noise levels in part to improve passenger comfort. The aircraft's hockey-stick-like Blue Edge main rotor blades have helped to reduce noise, while the use of the Fenestron antitorque system reduces noisy interactions between the two dynamic systems. The engineering team has prided itself on not having to use sound- and vibration-cancellation systems in the cabin, although they are an option for VIPs' aircraft.

The H160's orderbook has been slow to fill, in part due to the ongoing weakness in the oil-and-gas market and because the aircraft is arriving slightly later on the market than originally planned. When launched, the aircraft was expected to hit the market in 2018.

However, the company has secured orders for several corporate and VIP-configured machines. Babcock, which signed a five-year agreement to purchase an undisclosed number of helicopters in 2018, is expected to use the H160 to support its emergency medical service business around Europe.

Assembly of production aircraft is well underway, with the second serial-number H160 flying for the first time in December. The aircraft also will form the basis of the French military's new Joint Light Helicopter to be used by the Air Force, Army and Navy; 169 machines will be purchased to replace four types in the inventory. This military order is expected to bring additional innovation with plans to use Thales' FlytX suite. Airbus plans to make FlytX with its touchscreen, widescreen display panels available for the commercial version as well.

In Siberia, Russian Helo Maker Invests To Grow

> INDIAN KA-226T ORDER IS PENDING FINAL SIGNATURE

> VRT-500 AND BAIKAL BIPLANE POISED TO ENTER FACTORY

Steve Trimble Ulan Ude, Russia

Leonid Belykh is preparing the Ulan Ude Aviation Plant for an improbably historic growth spurt. Belykh started working at the sprawling aircraft factory deep in the Siberian taiga 50 years ago as a circuit installer, so now, as general manager, his paternal pride shows as he rattles off a list of capital investment projects, starting with a newly opened paint hangar.

"This is one of our investment projects: More than 1 billion rubles ($16.3 million)," Belykh says through an English translator.

Belykh then points to a half-finished construction site, with aluminum panels half-enclosing a frame of steel beams. "The new logistics center: [also] more than 1 billion rubles. You also see the press and decal production center: also around 1 billion rubles. We plan to build a new galvanizing shop: also 1 billion rubles. The overall investment over the last five years: more than 8 billion rubles. We plan to have approximately 10 billion rubles investment in the next 10 years."

Such capital spending would have seemed unlikely only five years ago. By then, orders by China for the Ulan Ude Aviation Plant's signature product—the multi-purpose Mil Mi-171 helicopter, the export version of Russia's

domestic Mi-8 medium-twin—had dried up as Chinese-built alternatives entered the market. Internal demand within Russia the Mi-8 continued, but not at sufficient levels to support three final assembly sites, including in Ulan Ude, Kazan and Moscow.

As Belykh scrambled to find new foreign patrons, India offered a lifeline. Needing to replace Cheetah and Chetak light utility helicopters for the air force and army, India's Ministry of Defense selected in 2015 the Ka-226T, Kamov's coaxial, light-twin reengined with Safran Arrius 2G1 engines. To support India's requirement for 200 helicopters, Rostec reassigned final assembly for the Ka-226 from a plant in Kumertau, Russia, to Ulan Ude.

Moreover, the remote Siberian factory also has attracted some of the Russian aviation industry's most innovative aircraft concepts, including potential production of the Baikal biplane. Though most Russian aircraft production centers concentrate on either fixed- or rotary-wing, Ulan Ude historically has assembled both, including the Sukhoi Su-25 attack jet. Russian Helicopters also has selected Ulan Ude to assemble the VRT-500, a light-single launched last year to serve the urban air taxi market.

But the potential growth for Belykh's Siberian aircraft plant still isn't assured. The new aircraft projects are based on new, uncertified designs. More important, India still hasn't consummated the Ka-226T selection five years ago with a signed aircraft order. Last year, reports emerged of friction between India and Russia over the amount of local content for Indian companies.

Russian Helicopters initially agreed to assemble the first 60 airframes in Ulan Ude, then install the French-made engines in India. Ulan Ude would continue to build up the airframe kits for the final 140 Ka-226Ts, but the remaining aircraft would be assembled in India. Last February, the Russian manufacturer announced agreements with five Indian companies to supply parts for the Ka-226T's fuselage, rotor blades, radios and landing gear, but other components will continue to be sourced from Russia's facility in Kumertau.

After a half-decade of negotiations, there are signs that the deal could be completed soon. In November, Alexander Mikheev, the head of Rosoboronexport, told reporters at the Dubai air show that he expected India to sign the contract before May 2020. President Vladimir Putin has personally intervened in the potential, $1 billion transaction, offering Indian Prime Minister Narendra Modi a tour of the aircraft during an event in Vladivostok in September.

The threat of U.S. sanctions does not seem to concern Russian officials. In response to Russian meddling in 2016 elections, the U.S. issued a blanket threat against any company that conducts a transaction with Rosoboronexport, Russia's arms export agency. More recently, U.S. diplomats have narrowed the threat to only certain transactions, excluding certain deals between traditional Russian customers. It is not clear how the narrower U.S. policy applies to the Ka-226T order, but Belykh dismisses any concerns.

"When you came here, you thought that the plant was stalled, that production was halted, that sanctions make it so we cannot build any more helicopters," he said. "But sanctions would not stop us from building our helicopters. It will not happen."

As an Mi-171 performed a flight test in September at the Ulan Ude Aviation Plant, Russian Helicopters was searching for new export customers, from Kazakhstan to India to Africa.

STEVE TRIMBLE/AW&ST

DAN PROSSER FOUND THAT WHAT HE LIKED AND WHAT HE WAS GOOD AT WERE ONE AND THE SAME— computer programming and simulations—while an undergraduate student at Rochester Institute of Technology. He took that interest to the Georgia Institute of Technology to earn a Ph.D. in aerospace engineering. His work in grad school is where he found his future, evaluating and analyzing simulations. "I like being on the cutting edge of the tools the Navy is working on—the aircraft and everything that goes on it," Prosser says. "I like the stability of working for the government. We have good benefits and vacation time. My work situation is good, and I have every other Friday off, and while salary [as a priority] comes after the life I wanted for my family, we are paid well."

OPERATING IN THE MESH

As naval aircraft grow increasingly complex, Prosser is involved with mesh generation. In this technique, a large area surrounding an aircraft in simulation is broken into small cells, with equations in each cell solved and then aggregated to identify how fluid dynamics form around the vehicle. Some mesh generations take months to run, and automation in software development is helping to make the operation more efficient. Prosser works with fellow aerospace engineer Jacob Allen (below) on the mesh-generation techniques that are used.

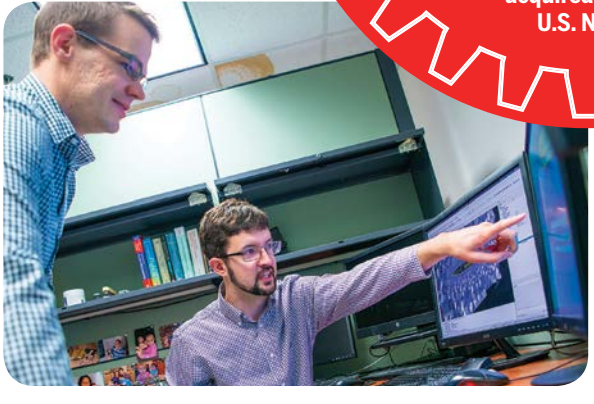
NAVAL AIR WARFARE CENTER'S

DANIEL PROSSER

One of Aviation Week's 20 Twenties in 2013, Presser provides program support at the Naval Air Warfare Center Aircraft Division, testing aircraft and systems being acquired for the U.S. Navy.

DEVELOPING AND PROVIDING TOOLS

Prosser's daily work involves assuring that tools being used to assess new aircraft and systems are doing their jobs, from computation simulations of fluid dynamics to basic quality assurance for the High-Performance Computing Modernization Program (HPCMP). He checks the varied simulations as they are running and how the data is coming in, and then he analyzes that data. The HPCMP provides the tools used in evaluating systems being acquired, including computational research and engineering acquisition tools and environment.



TEACHING THE TOOLS

In addition to assuring the quality of the simulation and evaluation tools, Presser's division assigns engineers to teach courses three times a year at varied locations to help users gain expertise. The tools, which assist programmers as they code software, come with use cases that allow the students to play with new features while allowing Prosser to contribute to how the code is developed.

U.S. NAVY PHOTOS

NETWORK NEWS

- **ISRAEL'S BNET DATA LINK HAS BEEN INTEGRATED ON F-35I**
- **OPAL COMBAT CLOUD SYSTEM RECENTLY DECLASSIFIED**
- **SMART TRIGGER NOW CLEARED FOR EXPORT MARKET AS FIRE WEAVER**

Steve Trimble Tel Aviv

This is the scenario: A soldier identifies a target—say, the third window from the left on the fourth floor of a nondescript structure deep inside a crowded city—but it is beyond the effective range of his rifle.

Now the search begins. The soldier needs to find a friendly "shooter"—an unmanned aircraft system (UAS), tank crew or even a Lockheed Martin F-35I—who is within range, carrying a weapon that is neither too big nor too small and, last but not least, can be verbally directed to the right window, even when viewed from a different angle. The process takes time, but it must be resolved before the target drifts to another floor or flees to another building.

Such a situation is one of the defining problems of modern warfare. This particular scenario involves a crowded, urban environment, but it applies anywhere—a clash with nonuniformed insurgents a few blocks down the street or armies operating long-range, mobile missile launchers spread across an operational theater spanning oceans, coastlines, mountains and deserts. To dominate a modern adversary, deploying weapons with sufficient precision and range is no longer enough. The urgent new challenge is to employ the right weapon from the right platform within seconds or minutes—not hours or days.

A tour of Israeli aerospace and defense companies in early January by Aviation Week revealed how far the Israeli Defense Forces (IDF) have come toward conquering this challenge. As a self-contained unit spared the restrictions of adhering to NATO standards, Israeli companies have developed and delivered a battlefield network for the IDF powered by high-bandwidth data links and an Android-like, common operating system.

At a time when the U.S. Air Force's pursuit of distributed battle management and command and control is limited to demonstrations of connecting fleets of different stealthy aircraft, the IDF has fielded combined arms units up to the battalion level with a system called Smart Trigger developed by state-owned arms supplier Rafael.

How does Smart Trigger work? A Rafael employee, who requested anonymity for security reasons, told

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By combining wideband data links, a combat cloud architecture and collaborative applications, the IDF has conquered the challenge of distributed command and control.

Aviation Week how the IDF's existing technology solves the urban threat recognition problem within seconds. Take, for example, the target on the fourth floor of the urban building.

Instead of keying a voice radio, the soldier presses a button on the "smart sight" of his M-16. The battlefield has already been indexed at the individual pixel level on a geospatial reference system. Moreover, each of the battalion's nodes, from the M-16 to the tank to the UAS, are using the same network. The press of the button on a soldier's weapon sends a tender, or request, to a processor on the network. The processor's operating system automatically invites each of the nodes to bid on the platform best placed to engage the target. The bid responses are evaluated on parameters that include whether they are close enough and carrying a weapon that complies with the rules of engagement. The network then selects the best option.

If the selected platform is the armed UAS, the drone's remote operator sitting in a ground control station receives automated notification as a target marker appears on the sensor display. The marker identifies the same window seen by the rifleman, but from the perspective of the sensor onboard the UAS. The UAS operator communicates by secure voice or video chat with the rifleman to confirm the target is still valid. If the solider confirms, the UAS operator is cleared to fire. In ideal terms, the entire "sensor-to-shooter loop," which involves multiple platforms and complex coordination, is closed in less than 10 sec.

The fundamental elements of the Smart Trigger system—a mobile, ad hoc mesh network; high-bandwidth data links; and a common, open architecture operating system—have evolved over decades but only recently have come together to form an operational network.

NATO forces have standardized around the Link 16 network developed under the the Joint Tactical Information Distribution System (JTIDS), a time-division-multiple-access (TDMA) network that provided a state-of-the-art capability to transmit and receive data between aircraft and ground stations at rates up to about 150 kbps when it was deployed in the 1980s and 1990s. Attempts within NATO to replace Link 16 with a modern, high-bandwidth internet-protocol-based network have largely failed, with certain one-off exceptions such as the Tactical Targeting Network Technology deployed on the U.S. Navy's E-2D fleet.

As a non-NATO member that prefers to operate independently, Israel's defense industry was never restrained by the limitations imposed by the alliance's rigid standards. As a result, Rafael developed and deployed the Ravnet-300 airborne data link for Israeli fighters 20 years ago, providing the Israeli Air Force with data transmission speeds an order of magnitude faster than those offered by JTIDS.

Given a relatively small, self-contained military, Israel also has another advantage compared to NATO: an ability to affordably upgrade networks over time. The introduction of faster microprocessors during the last decade, such as the Intel i3, allowed Rafael to take the next step. Although somewhat unnoticed outside the country, the IDF has deployed Rafael's new BNET data link across the military over the last five years. In a largely unheralded achievement, Rafael has integrated BNET on the F-35I—one of the key upgrades, along with an Israeli electronic warfare suite, for Israel's unique variant of the Lightning II.

"If our competitors talked about one, two, five or 10 [Mbps], we talk about 20 and 40 [Mbps] on the reception rate," another Rafael employee says, describing BNET.

As a software-defined radio, the BNET data link is able to transmit and receive using multiple waveforms, solving one of the hardest

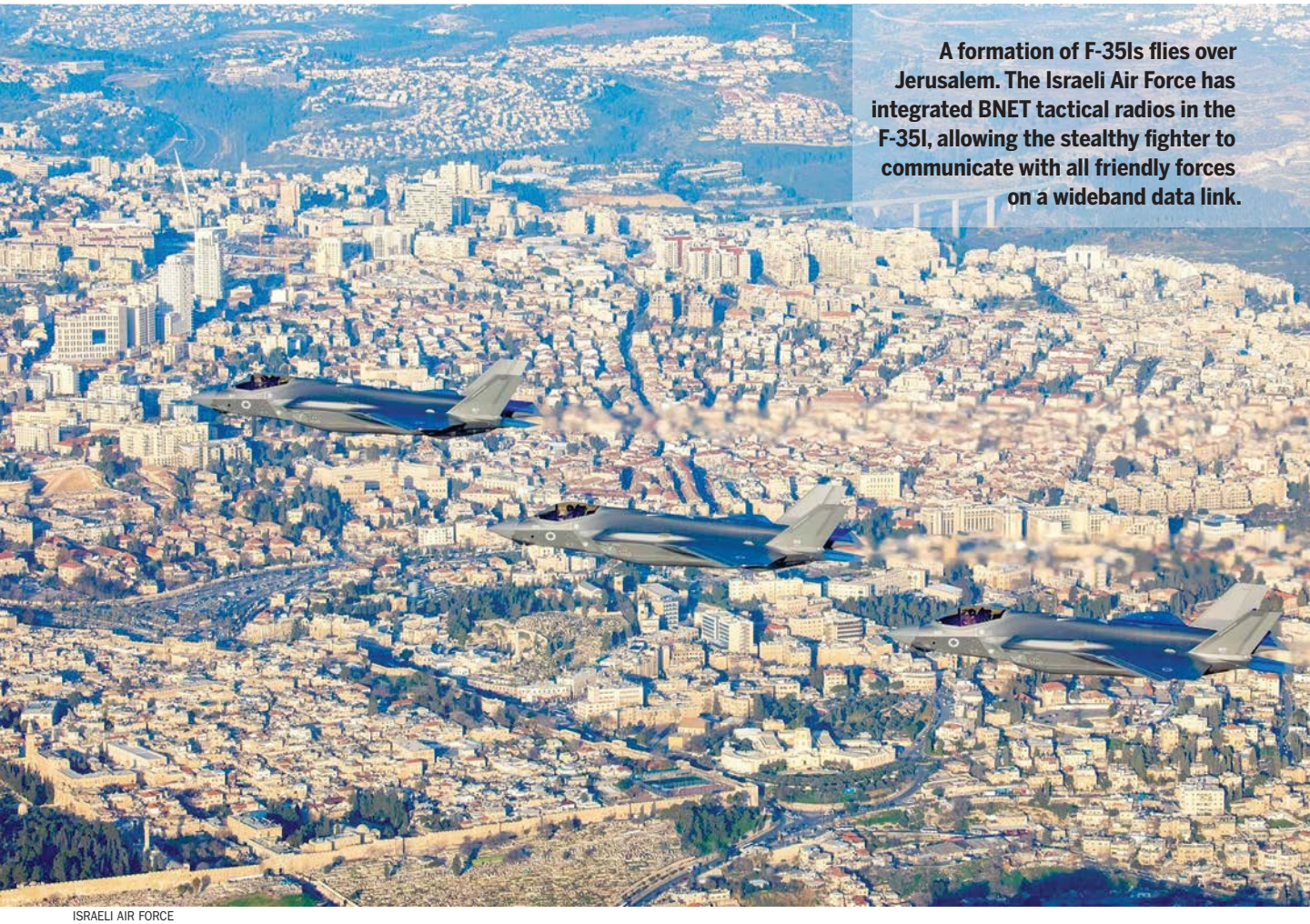
problems of interoperability within a military. By using a directional antenna with a narrow 1.2 deg. of divergence, transmissions have a low probability of intercept.

But a network based on software-defined radios implies another critical shift in military communications. It is similar to the difference between communicating by a walk-talk to helicopters, and another radio to receive videos from different sources. Now, all this is done in a single box: common voice, video and data."

But the communication system is only part of the IDF's capability. In addition to a common network, the IDF also has deployed a fully developed combat cloud. In 2019, the IDF first declassified the Israel Aerospace Industries (IAI) command and control system called Opal. In reality, Opal is a box that is installed on the IDF's various platforms. By plugging Opal into a network such as BNET, the IDF's units are able to share a common operational picture that displays real-time situational awareness with multilevel security, depending on the user's access. It is similar to a wide-area network in an office building, but deployed on moving platforms in a battlefield environment.

In an aircraft, Opal connects to a military standard 1553 databus or fiber-channel databus and downloads the data collected by the sensors, says an IAI employee. The aircraft's sensor information is now available on the network, using BNET or any other data link. The system also includes an application framework layer, allowing users to develop their own "apps."

The overall system, including the BNET data link, Opal combat cloud and Smart Trigger application, are already in operation by the IDF. Some elements, including Opal, were introduced over 15 years ago, while others, such as BNET, appeared in the last few years. The IDF now has cleared the technologies for sale on the export market. The BNET is offered as Global Link, and Smart Trigger is sold to foreign militaries under the Fire Weaver brand. Export customers for BNET now include India, which is deploying hundreds of the radios within its military, Rafael says.



A formation of F-35Is flies over Jerusalem. The Israeli Air Force has integrated BNET tactical radios in the F-35I, allowing the stealthy fighter to communicate with all friendly forces on a wideband data link.

ISRAELI AIR FORCE

ie-talkie and a smartphone. Traditional military radios are designed to communicate only with other radios sharing the same frequency. A commercial smartphone, by contrast, is designed to communicate with any other compatible device, even those that do not share the same network or operating system. The BNET uses a similar approach.

"Coming from the military side, usually for every type of communication, there's a special box," the Rafael employee said. "You have one radio to talk to an aircraft, another radio to

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New Space Embrace

> RAFAEL WINS SECRET SATELLITE ORDER

> IAI CONSIDERS ON-DEMAND LAUNCH SERVICE

Steve Trimble Tel Aviv

After entering the space business more than 30 years ago, Rafael's strategy has added a recent twist. No longer content to remain a subcontractor for satellites and rocket launchers, Israel's second-largest state-owned aerospace company has decided to challenge Israel Aerospace Industries' (IAI) grip on the military space market at the prime contractor level.

Although some details of Rafael's progress and plans are classified, the Haifa-based company confirms it has made significant progress in a new quest to become an international leader in the military sector of the New Space market.

A customer, whose identity and mission remain "very secret," has selected Rafael to develop and deploy a new satellite constellation in 2022, Rafael officials tell Aviation Week. During the same year, Rafael also plans to launch a company-funded satellite constellation for research purposes, officials say.

The spacecraft for both of Rafael's future constellations fall within the niche of nanosatellites, a category defined by a mass less than about 10 kg (22 lb.). The development of such proliferated constellations for low Earth orbit (LEO) has spawned multiple "New Space" startups in North America, Europe and Asia focused mainly on the commercial market, but the trend had largely bypassed Israel's broad and mature space industry—until recently.

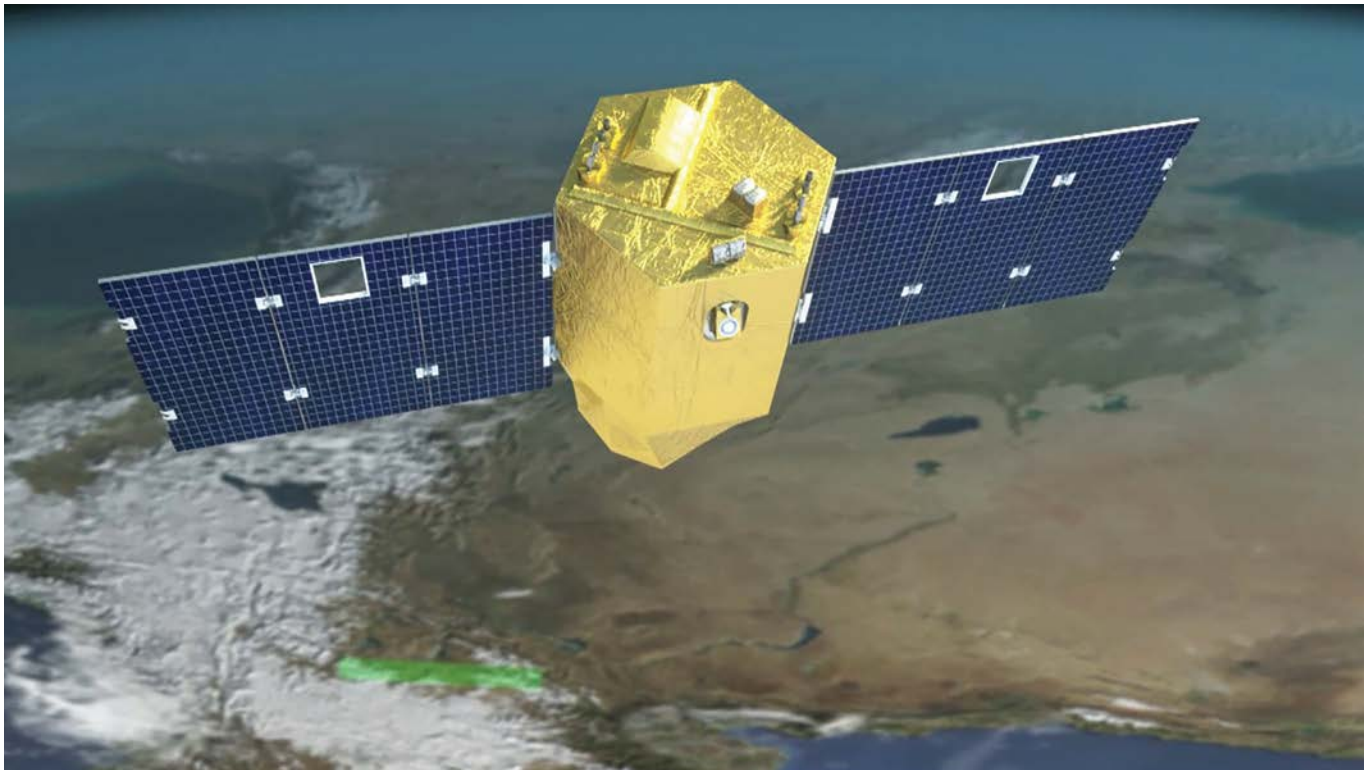
But the New Space trend now has firmly arrived in Israel, with a familiar local tilt toward the military sector. During Aviation Week's recent tour of the country's aerospace industry, all three major prime contractors—Elbit Systems, IAI and Rafael—confirmed active development in the New Space market, although mainly focused on military clients rather than commercial customers.

The transition implies a major shift in direction for Israeli companies that have previously specialized in building and launching large, sophisticated spacecraft from purpose-built rockets, but industry officials agree that change is necessary.

"If we stay in the same place, the market will move away," says Boaz Levy, general manager and executive vice president of IAI's Systems, Missiles and Space Group. "So we need to follow the market, and that's what we are doing."

In fact, IAI launched a 5-kg nanosatellite into orbit in 2017 for a company-funded research mission. But that was only the first step. The company is now working on plans to develop a proliferated constellation in LEO using spacecraft weighing up to 12 kg each, Levy says. Startups have the technology to develop commercial products, but only established space companies like IAI have the capabilities to pursue more sophisticated

IAI



A key to Rafael's ambitions in the New Space market is the electric propulsion system set to be engaged this year on the joint French-Israeli VENuS satellite (above).

market niches, such as space-based, space situational awareness for military customers, he said.

"This is something that the big companies can bring to the table because it requires all of the data that was on the big satellites as well," Levy says.

Another IAI capability—space launch—is ripe for expanding in the New Space era. Despite Israel's geographic position, which requires energy-consuming westward launch trajectories, IAI already supplies the Shavit rocket with the capability of lofting payloads up to 250 kg into orbit. The company is also interested in adding a new capability for on-demand launches, Levy says. As such, the Haifa-based aerospace manufacturer is analyzing several options for on-demand launch systems. Asked if IAI was considering only ground-launched options, Levy replied: "Not necessarily."

Elbit Systems, an established supplier of advanced electro-optical camera payloads for satellites, also has moved toward entering the New Space field. In December, Elbit successfully launched the 5 kg Nanova satellite with a communication payload into a polar orbit. The Nanova, which was developed with an American company, resulted from a "medium-level" internal investment in nanosatellite technology, says Joseph Gaspar, Elbit's executive vice president and chief financial officer.

"We are not really sure at this point in time how this market is going to develop," Gaspar says. "We're keeping our hands on that technology. But if you ask: 'Do we invest a lot of money in that?' I would say, no. We do invest, and if something explodes in that area we will be able to bring our solutions."

The challenges of adapting nano- and small-scale satellites to a military application are not trivial. Complementary metal-oxide-semiconductor (CMOS)-based electro-optical sensors are deployed on commercial nanosatellites, but the rules of physics in such a small payload limit image resolution to about 3-5 m. For the purposes of identification, tracking and targeting, military operators often require resolution at the sub-meter level.

This is where Israeli aerospace industry's depth in developing space and airborne sensors, lightweight materials and advanced analytics may come into play.

"So the question is, how can we do the same thing in that same package and make it better," a Rafael employee says.

One approach is to adapt the system to a military customer. A commercial startup such as Planet Labs constructs an updated, composite image of the Earth every day, albeit at a resolution of about 3-5 m. That suits the requirements for a diverse commercial customer base needing only aggregated data. But a military operator is usually interested in revisiting only certain areas daily rather than the entire planet, the employee says.

"So maybe in our solution we could be a bit more humble and not image the whole world, but bring better value to a defense customer because we're only going to be imaging the area that's interesting to him and so maybe produce that higher resolution," the Rafael employee says.

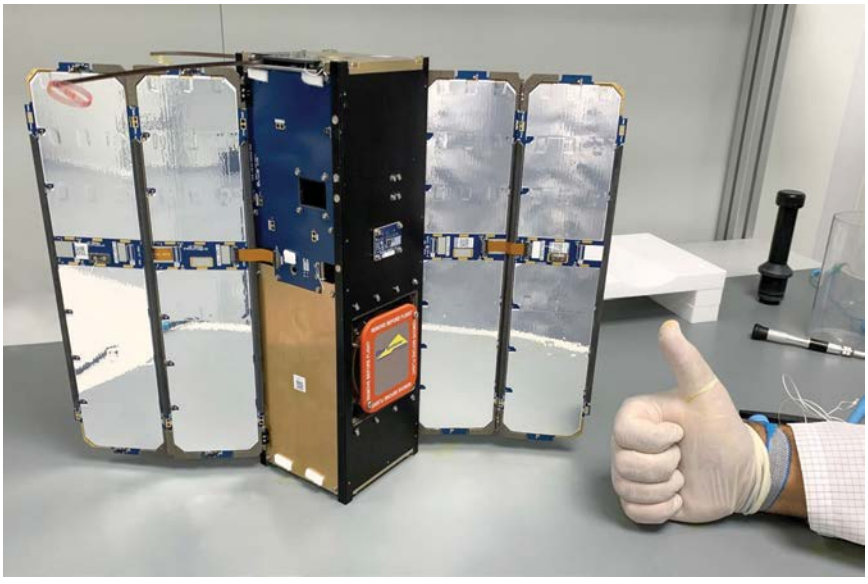
Another factor in Rafael's favor, the employee adds, is the company's experience in the airborne market. The company's Lightning 5 targeting pod, for example, has improved significantly over five generations, but the size and weight of the sensor has not changed, the employee says. To that end, aerospace companies understand how to make generational improvements in sensor quality without increasing the size of the payload.

"We're taking that capability and applying it to our space payloads, getting the most amount of resolution while still confining ourselves to a small size," the employee says. "For example, we could put that same size inside a more advanced electro-optical design that allows multiple sensors. Then, all of a sudden, you're getting resolution and you're getting swath."

Israel's space industry also has unique technologies in development. One of the factors that determines the image resolution of a nanosatellite is the altitude of the orbit. A lower altitude produces sharper images, but the relatively higher concentration of atmospheric molecules increases the drag. The exposure to greater atmospheric resistance limits the spacecraft's lifetime in orbit.

However, two decades ago Rafael started working on a potential solution to this problem: a family of small, subkilowatt electric propulsion systems. In partnership with the French space agency CNES, the company is set to test a Hall effect thruster in orbit this year. IAI's Vegetation and Environment monitoring on a New Micro Satellite (VENuS) launched in August 2017 to an altitude of 720 km. By activating Rafael's R-400EPS thrusters, the satellite will reposition later this year to a lower altitude of 410 km.

"If I have an amazing electric propulsion system in-house, I'm able to go to lower altitudes," the Rafael employee says. "I'm able to [do so] with the same satellite image at higher resolutions and be able to have a longer life. When everyone out there is talking about electrical propulsion, I actually have one."



ELBIT SYSTEMS

Two Israeli aerospace contractors have launched nanosatellites, including Elbit's Nanova (above) spacecraft, as they research options for launching future constellations in low Earth orbit.

Industry Evolution Continues Amid Israeli Political Crisis

> MINORITY OFFERING FOR IAI SET TO MOVE FORWARD

> COMMERCIAL DIVISION'S WEAKNESS HAS BEEN MITIGATED

Steve Trimble Haifa and Tel Aviv, Israel

A yearlong political crisis that has paralyzed policymaking and procurement decisions seems to have bypassed Israel's aerospace and defense industry. Instead of waiting patiently for Israeli voters to finally approve a permanent government, the industry has accelerated what company executives have called a long-overdue internal transformation.

Most recently, Israel's defense ministry approved a proposal to allow Israel Aerospace Industries (IAI) to publicly offer a minority of shares in the company to private investors. The prime minister's office has yet to make a final decision, but IAI's management has never come closer to fulfilling a 20-year-old proposal for the initial public offering (IPO).

Moreover, two of Israel's industry stalwarts have addressed two areas of financial weakness over the last year. In 2019, Elbit Systems consummated a six-year-old plan to acquire formerly state-owned and financially fragile Israel Military Industries (IMI), the maker of the Delilah cruise missile and other munitions. Rafael subsequently acquired Aeronautics, a previously independent manufacturer of small unmanned aircraft systems. Meanwhile, IAI has reorganized a commercial aircraft division responsible for $600 million in losses over the last decade.

The chances of further consolidation seem remote. In June, IAI Chairman Harel Locker, the prime minister's former chief of staff, told Aviation Week that a merger with Rafael, the second-largest, state-owned defense company, was necessary and "inevitable." By October, however, Locker had backed off those statements, telling the Israeli press there were no plans for any such move.

Instead, IAI is preparing for an IPO that is expected to produce a financial windfall of about 4 billion shekels ($1.16 billion), the proceeds of which would be split between the state treasury, the defense ministry and IAI.

The partial privatization also would add momentum toward efforts to reform IAI's business culture. The company's commercial aircraft business

Israel's aerospace industry is seeking to become more competitive through consolidation and by reforming traditionally underperforming sectors such as IAI's commercial aircraft division and the recently acquired Israel Military Industries.

IAI

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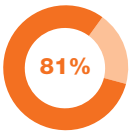

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traces its roots to within four years of Israel's independence in 1948, but that segment has struggled in the last decade. Demand for IAI's converted Boeing freighters was inconsistent, and the company failed to make a profit as a subcontractor building G280 business jets for Gulfstream. During the last year, IAI has consolidated the aircraft business from three units into a single division.

Elbit faced a similar challenge to absorb IMI, another state-owned business that operated at a loss. Still, privately owned Elbit considered IMI a good match, pairing the latter's munitions with Elbit's electronics. By combining both portfolios, Elbit plans to launch new and improved weapons for foreign and domestic customers.

In fact, Elbit has already won the first such contract to develop a new weapon based on IMI's products, says Joseph Gaspar, Elbit's executive vice president and chief financial officer.

Gaspar declined to offer further details, citing security restrictions.

"You take whatever they have done and put in a lot more electronics with more software and things like terrain-following radar, correlations and image identification," Gaspar says. "By the way, we're not talking now just to communicate to that missile or to that rocket. We're talking now to communicate between several sources so that you optimize the trajectory to hit at the right place.

ELBIT SYSTEMS

Joseph Gaspar, chief financial officer of Elbit Systems

"We acquired a losing business, but we also paid according to the money," Gaspar continues. "So I think it's a good deal, both financially and from the strategic opportunities that we have today."

Indeed, Elbit expects a "small operational profit" for IMI's financial finish to 2019, Gaspar says, a turnaround after years of red ink.

The goal now for IMI is to enlarge the business, especially on the export market. Before the merger, about 80% of IMI's revenues came from Israel's defense ministry, a rarity in Israel's export-oriented defense industry. Elbit's relationship with IMI during 2019 opened the company's sales prospects, leading to a significant rebalancing.

"It's actually closer to 60/40 now. That is 40% international and 60% Israeli," Gaspar says. "Looking into the future, I think we'll bring them up to the [Isareli average]—maybe not 80% exports, but maybe 70%."

Israeli UAS Market Shifts From Platforms to Networks, Gap-fillers

> RECENT CONTRACT WIN TIPS OFF NEW STRATEGY

> MICRO-UAVS, LOITERING MUNITIONS GAIN TRACTION

ELBIT SYSTEMS

Steve Trimble Haifa and Tel Aviv, Israel

A $153 million contract award announced by Elbit Systems on Oct. 6 last year did not seem obviously significant. A Southeast Asian country had ordered a package of the Israeli company's unmanned aircraft systems (UAS), including thousands of THOR mini-UAS, "scores" of tactical Skylark UAS and the medium-altitude long endurance (MALE) Hermes 450, which is already operated in the region by Singapore and Thailand.

But the order was anything but routine. Within the Haifa, Israel-based UAS and defense electronics company, the program itself offered validation of a strategic shift in the UAS market that is reshaping the competitive landscape in Israel and potentially beyond.

"That's a strategic change," says Joseph Gaspar, Elbit's executive vice president and chief financial officer. "But I'm not sure everybody has understood that yet. What we see in the market is that whoever has the capability to integrate all of this—from communication channels to artificial intelligence to smart ground stations and smart airborne platforms—has a significant advantage. And now we're not competing on UAV vs. UAV, per se. But you are competing on the solution of a system."

A decade has passed since the first flight of the Hermes 900, Elbit's last major product in the MALE UAS category. It has been even longer since first flight, around 2004, of the Israel Aerospace Industries (IAI) Heron TP, a 5-ton MALE UAS in the same mission class as the General Atomics Aeronautical Systems (GA-ASI) Predator B. Meanwhile, Israel and the U.S. have lost a duopoly position in the MALE UAS market, as new competitors have emerged in Italy, Turkey and China.

The U.S. Defense Department has continued expanding its large-UAS inventory over the past decade by disclosing the existence of the GA-ASI Predator C, Lockheed Martin RQ-170 and funding development of the Boeing MQ-25. Similar programs to develop stealthy, large UAS have emerged in Russia and China.

Israel, meanwhile, has taken a different approach in the export market. Although the country remains active in bidding competitions for MALE UAS in Canada, Europe and elsewhere, there are no acknowledged plans by Elbit and IAI to develop a replacement for the Hermes and Heron UAS families.

Instead, the companies have been focusing on new ways to improve the value of the existing platforms while filling gaps as new niches in the market gain popularity, such as vertical-takeoff-and-landing drones and the next wave of loitering munitions.

The Southeast Asia order last October reflected that shift in market strategy. Instead of developing large new platforms, the emphasis is on improving the enablers for a network-based solutions approach, Gaspar says.

"If we're talking about this solution, then there is a lot of value in improving the communication links between the different platforms," says Gaspar. "You have to do some processing on the platform itself so you transmit what's really of interest. So you have to put artificial intelligence on the platform. It's a combination of requirements that, by the end of the day, provides a real-time, updated, situational reconnaissance picture."

Elbit Systems unveiled the Hermes 900 over a decade ago but has since shifted from a platform-centric to a solution-oriented approach for the UAS market.

The trend also shows in the types of new UAS that have appeared on the export market the last two years. Instead of large, multipurpose platforms, the industry has invested to fill a variety of niche UAS categories for a variety of military operations. An example is the Elbit MAGNI, a vehicle-launched, multirotor microdrone for land forces, unveiled in November. Likewise, IAI announced in 2018 a project to integrate a BirdEye 650D UAS on a RoBattle Unmanned Ground Vehicle.

RAFAEL

Israel started using fixed-wing loitering munitions in the 1990s, but the technology continues to evolve, including Rafael's newly launched vertical-takeoff-and-landing Firefly.

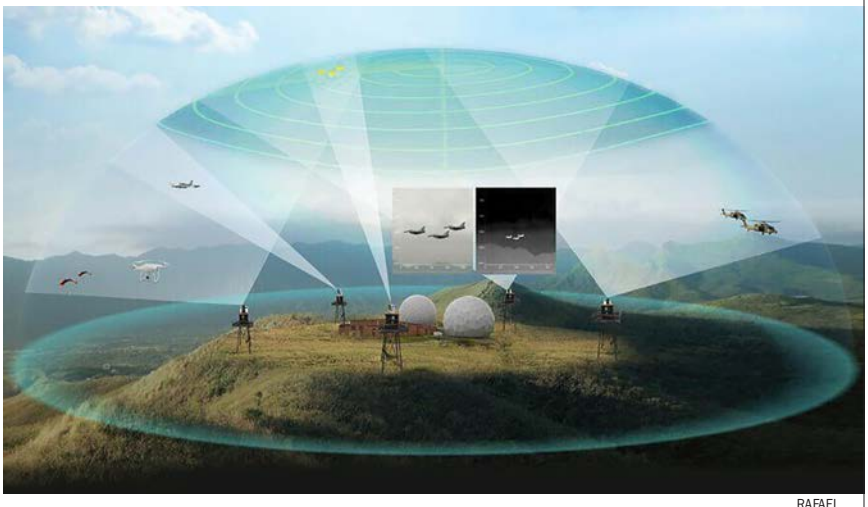
Moreover, Israeli industry has picked up on increasing demand for loitering munitions, a category IAI helped popularize in the 1990s with the anti-radiation Harpy UAS. In 2019, IAI revealed the "Mini Harpy," a 45-kg (99-lb.) loitering missile designed to strike a variety of targets, including radars. Rafael also picked up on the trend by unveiling Firefly, a loitering munition with vertical-takeoff-and-landing capability.

"The Firefly is maybe the only munition in the world that you send on a mission and, if it doesn't attack a target, you press 'home' and it comes back," a Rafael employee says. "So it's actually a flying grenade that comes back to you."

Declassified Sensors Fill Cracks in Israeli Air and Missile Defense Net

> RAFAEL ELABORATES ON NEW SKY SPOTTER TECHNOLOGY

> UPGRADE IN DEVELOPMENT FOR IRON DOME'S PRIMARY SENSOR



RAFAEL

Steve Trimble Haifa and Tel Aviv, Israel

Israel's multilayered surveillance network is evolving as local threats have expanded to include Russian stealth fighters, Iranian precision-guided rockets and kite-borne explosives from Gaza.

And as Israel's defense industry works to field a new generation of powerful S-band air and missile defense radars, the country's borders are now ringed by a recently declassified network of stealth-exposing, ground-based infrared sensors.

Observers at the Paris Air Show last year noticed a display at the Rafael pavilion showing a new infrared wide-area surveillance sensor for export customers called Spy Spotter. Although it had been recently declassified by the Israel Defense Forces, Rafael executives still were not allowed to comment on the display during the show or provide any further details of the system to foreign journalists.

Some of the restrictions have since been lifted, and Rafael agreed to speak about unclassified details of the system for the first time in early January.

A chain of overlapping Sky Spotter sensors now on Israel's borders is scanning a 20 X 90-deg. box of the country's airspace for incoming threats, with the capability to detect the infrared signature of fighters—stealthy or conventional—at distances of 30-60 km (19-37 mi.). The system makes use of a midwave infrared sensor (MWIR), says a Rafael employee, who requested to remain anonymous for security reasons.

By using geometric processing techniques from multiple angles, the wide-area MWIR sensors are able to classify and track the target as well as determine its speed and trajectory, the Rafael employee said. The Sky Spotter can then slew a narrow-field-of-view, short-wave infrared camera, an ideal sensor to penetrate light clouds or haze, or a charged-coupled device, like a telescopic sensor, to identify the target, the employee said.

The system also can receive cues from radars or radio-frequency receivers to provide a visual identification of a target, rather than just its signature in the radio-frequency spectrum, the employee adds.

Israel's interest in such technology is specifically security related. It fills a gap in an extensive radio-frequency-based surveillance net for targets with a low-radar cross section or those aircraft that have an unclear signature. A recent move by Gaza-based insurgents to loft explosives over the border on kites and balloons offers a case in point. Such an improvised weapon has little signature in the radio-frequency spectrum, but they show up clearly on Sky Spotter. A software update shortly after the attacks began allowed the system to automatically detect and classify such targets, the Rafael employee says.

The declassification of the sensor allows Rafael to export Sky Spotter, and the company has identified a potential market broader than traditional military purposes. In November, for example, the airspace in Washington, D.C., was shut down briefly because air traffic surveillance radars mistook a large flock of birds for a potential unauthorized aircraft. Adding a wide-area optical sensor to the surveillance network can prevent such costly errors.

Optical systems have joined Israel's air surveillance net. Rafael's declassified Sky Spotter uses a combination of sensors to detect missed targets or those hidden from radar.

Meanwhile, Israel continues to improve the country's elaborate radio-frequency-based surveillance network for air and missile threats. An order signed in December by the Czech Republic is the first export sale of an improved version of the ELM-2084 Multi-Mission Radar, the primary sensor for the Iron Dome low-altitude air defense system.

Elta Systems—the radar house of Israel Aerospace Industries—introduced gallium-nitride semiconductors in the active, electronically scanned array (AESA)-based ELM-2084 over a decade ago, but the most recent version deployed by Elta uses a more powerful, second-generation version of the processor material.

A company official also confirmed that Elta has started development on a further improvement of the ELM-2804 with a third generation of gallium-nitride material. The upgraded version is jointly funded by Israel's defense ministry and Elta's internal research and development budget. Each improvement drives a generational leap in processing power. The range of a radio-frequency system is a function of transmitter power and aperture size. Given that Elta has not adjusted the aperture of the ELM-2084, any increase in range must be driven by more powerful and efficient uses of gallium-nitride material. In this case, Elta is still designing the new version of the ELM-2084, but the company expects a 10-25% increase in detection range, depending on the final configuration and when it is fielded.

RAFAEL PHOTOS

Israel's Precision Munitions Embraced by U.S. Market

> U.S. ARMY SELECTS SPIKE NLOS FOR AH-64E

> RAFAEL TEAMS WITH LOCKHEED MARTIN FOR SPICE 1000 PITCH

Rafael's Spike NLOS has become a popular munition option for helicopters since Israel declassified it a decade ago. It will now enter the U.S. military's weapons inventory.

Steve Trimble Haifa, Israel, and **Lee Hudson** Amarillo, Texas

Rafael's precision weapons are on a roll in the U.S. market. Only a few months after Congress approved funding to buy the Iron Dome air defense system, the U.S. Army decided to buy the Israeli munition specialist's long-range, anti-tank missile for the Boeing AH-64E. Rafael also has teamed up with Lockheed Martin, a traditional competitor, to offer a precision-guided, 1,000-lb. bomb to the Air Force.

The new interest from the world's largest weapons buyer marks a change. In the past, the U.S. Defense Department has acquired other types of Israeli military technology such as unmanned aircraft systems, sensors and electronics, but with a few minor exceptions the U.S. has preferred to buy large numbers of precision weapons from domestic suppliers.

Nonetheless, Israel's weapons technology has become more attractive as requirements for navigation, guidance and, in some cases, range adapt in response to new threats. As threats have shifted from insurgents and rogue states to great power competitors that can jam satellite signals, military planners in the U.S. are scrambling to find alternatives to GPS navigation for precision weapons.

The GPS access problem is already felt in Israel. Gideon Weiss, Rafael's deputy general manger for business development, marketing and strategy, noted in a Jan. 1 interview with Aviation Week that his office in Haifa sits 40 km (25 mi.) from the Israeli border where Russian forces based in Syria use electronic warfare.

"The entire spectrum is now compromised," says Weiss, a former Israeli Air Force F-15 pilot.

The guidance dilemma—along with new interest in long-range weapons—are driving the Army to consider alternatives to the AH-64's standard munitions, which include the Lockheed Martin AGM-114 Hellfire missile and guided rockets. In the long term, the Army plans to acquire a Long-Range Precision Munition (LRPM) with a range greater than 25 mi. In the meantime, the Army is moving forward with an interim acquisition of Spike Non-Line-of-Sight (NLOS) missiles.

Late last year, the Army Requirements Oversight Council approved a "directed requirement for an interim capability, but that will be a limited fielding," said Brig. Gen. Walter Rugen, director of the Army's cross-functional team for Future Vertical Lift.

The decision comes five months after the Army staged a demonstration of the Spike NLOS on the AH-64E in late August at Yuma Proving Ground in Arizona. The Army's testers fired the Spike from an AH-64E hovering 200 ft. above the highest obstacle on the range. The target was a mockup of a Russian Tor M1 air defense system 28.5 km. away. Moments before impact, the testers intentionally shut off a data link used to send guidance updates to the missile to see if would still hit the target. "It did so in a fiery explosion," stated an Army report on the test.

Israel first demonstrated the maturity of the weapon decades ago. Although declassified in 2011, Israel's domestic version, called Tammuz, was developed based on lessons learned from the Yom Kippur War in 1973, when Israel was invaded by waves of heavy armored divisions launched almost simultaneously by Syria and Egypt. The Tammuz was developed secretly to use in a surprise counterattack. By the mid-1990s, the Israel Defense Forces had also developed the capability to have the Elbit Systems Hermes 450 serve as a tank-spotter for a Tammuz launched by aircraft such as the AH-1 Cobra.

The Spice 1000 has become Israel's go-to weapon for air strikes in Syria.

Rafael's large, precision-guided bombs, including the Spice 1000, were developed with a similar guidance doctrine. An onboard scene-matching algorithm compares an image from the electro-optical seeker to an image in the computer's threat library. If the scene-match is correct, Spice automatically acquires the target and homes in on the location provided by the seeker.

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Aerospace Calendar

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Feb. 11-16—Singapore Airshow. Changi Exhibition Center. Singapore. See singaporeairshow.com

Feb. 13-April 2—RTCA Plenary Sessions. Various locations. See rtca.org/content/upcoming-committee-meetings

Feb. 18-19—Aviation Festival Asia. Suntec Singapore Convention & Exhibition Center. Singapore. See terrapinn.com/exhibition/aviation-festival-asia/index.stm

Feb. 25-26—Paris Space Week. Air and Space Museum. Paris. See paris-space-week.com

Feb. 25-26—AIME-Aircraft Interiors Middle East. Dubai World Trade Centre. Dubai. See aime.aero

Feb. 25-28—Aerospace Europe Conference (AEC2020). Bordeaux Congress Center. Bordeaux, France. See aerospace-europe2020.eu

Feb. 26-28—2020 Air Warfare Symposium. Rosen Shingle Creek Hotel.Orlando, Florida. See afa.org/events/calendar/2020-02-26/air-warfare-symposium

Feb. 29—GoFly Final Fly Off. Moffett Federal Airfield. Santa Clara County, California. See goflyprize.com

March 2-3—U.S. Naval Institute/AFCEA International WEST Conference. San Diego Convention Center. San Diego. See usni.org/events/west-2020

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

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

Feb. 5-6—CAPA Qatar Aviation Aeropolitical & Regulatory Summit. Doha, Qatar.

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

March 2-3—CAPA Middle East & Africa Aviation Summit. Dead Sea, Israel.

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

March 9-11—Commercial Aviation Industry Suppliers Conference. Beverly Hills, California.

March 9-11—Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.

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

March 12—Aviation Week Laureates Awards. Washington.

April 1-2—CAPA Airline Leader Summit: Making Money 2020. Dublin.

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

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VIEWPOINT

When Not To Fly

By **Mark Zee**

Until Ukraine International Airlines Flight 752 (PS752) was shot down just before dawn in Tehran on Jan. 8, the tempting narrative was that the destruction of Malaysia Airlines Flight 17 in 2014 was a black swan event.

Iran's acknowledgment that it shot down PS752 removes that doubt and painfully validates our 5.5 years of work on airspace risk awareness, but it also makes clear that this work was not enough to prevent a repeat tragedy. It is now evident that governments must play a more active role in preventing airlines from flying in conflict zones.

The work the aviation industry has done post-MH17 has not been for nothing. Far from it. Cooperation and collaboration around risk among airlines and among government departments, which was largely frowned upon before MH17, has become acceptable.

Risk awareness is higher than ever before. Information-sharing has moved from small, closed circles to large, open groups.

But underlying that work was an uncertainty around the need for it all. The reason: Risk is nebulous.

A decision to avoid risk averts a situation that might occur. Despite the usual scales of low, medium, and high, the true likelihood is always low. There is no data to provide answers afterward: What did not happen cannot be measured. Airline security managers are therefore under tremendous pressure. Money spent on risk avoidance has no clear billing code. But the temptation to err on the side of saving costs is ever present.

Herein lies the impasse. The ultimate final decision in approach to risk lies with the airline or aircraft operator, which is in most cases a business. Passengers and pilots have an undeniable first priority to stay alive.

A business has the same priority, of course. Every decision in a business will ultimately be a commercial decision to ensure it stays alive. This explains why airlines continued to fly to Tehran even when it was abundantly clear this was a shootdown event.

A lesson from the last five years of our work is that like businesses under pressure to fly through conflict zones, countries cannot be relied upon to close risky airspace or issue damaging guidance about their own territories. Iran is not alone in this. A string of other nations have made similar decisions: Cyprus, Egypt, Ethiopia, Iraq, Japan, Kenya, Libya, Mali, North Korea, Somalia, Syria and Turkey. Only on one occasion—Pakistan, in 2019—has a national authority closed its airspace for reasons of conflict-zone risk. Governments have more pressing motivations in trade, tourism and commerce. This will not change.

And yet government involvement is what is needed to solve things. The civil aviation industry has done what is within its power—there are no new initiatives that can take us further.

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LIKE BUSINESSES UNDER PRESSURE TO FLY THROUGH CONFLICT ZONES, COUNTRIES CANNOT BE RELIED UPON TO CLOSE RISKY AIRSPACE.

The position that aircraft operators are solely responsible for making risk decisions favors the handful of large airlines that have the resources to continually assess risk. The overwhelming majority cannot. For thousands of operators, relying on internal or external support to make qualified, informed essential risk decisions is simply not practical. The operational staffing of even a medium-size airline is small, especially at night, when most rapid-onset risk situations occur.

Right now, only a handful of countries are active in prohibiting their carriers from risky areas. But it works.

On the night in question, the U.S. had issued a notice to airmen that prevented its pilots and carriers from operating in Iran, several hours before the shootdown. If there were going to be an incident, it would not involve a U.S. aircraft.

When the U.S. prevents its carriers from flying through a conflict zone, many airlines follow—especially when backed up by Germany, France or the UK. But no system, organization or clear channel exists for that information to be passed to all concerned. This must change.

Each state has a duty to care for its citizens. Most governments have the resources to assess risk. This duty of care needs to be extended to pilots and passengers aboard aircraft.

In the first weeks of 2020, international travel advice about Iraq and Iran from the foreign affairs departments of many countries was clear: Do not travel. That same advice needs to extend to aircraft operators: Do not fly.

Mark Zee is the founder of Opsgroup, an organization of 7,000 members working in international flight operations that share information to improve awareness of risk, operational procedures and changes after MH17 exposed the lack of collaboration in the industry. He also manages Safe Airspace: The Conflict Zone & Risk Database.

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