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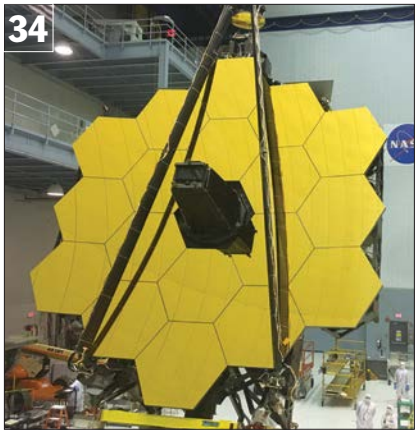
Contents

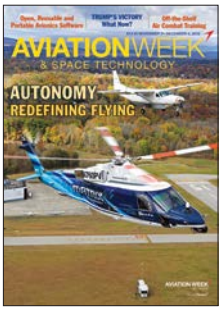
Volume 178 Number 24

AVIATIONWEEK & SPACE TECHNOLOGY

Digital Extras *Tap this icon in articles in the digital edition of* **AW&ST** *for exclusive features.*

The U.S. Army has adopted the Future Airborne Capability Environment—aiming for avionics software portability between aircraft—for its Future Vertical Medium Lift mission system, whichever rotorcraft it selects.





ON THE COVER

Lockheed Martin Sikorsky's S-76B SARA autonomy testbed flies with a modified Cessna Caravan over the ground-station van at Poughkeepsie, New York, in a demonstration of advanced cockpit automation under DARPA's ALIAS program (page 57). Sikorsky photograph by Ted Carlson. Elsewhere in this issue are columns and analysis of the implications of Donald Trump's election as U.S. president (pages 13, 16, 18-22 and 66), a special report on the growing practice of hiring contractors to test the mettle of military pilots (page 36) and a look at a truly portable and reusable software developed for airborne applications (page 55).

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AVIATIONWEEK
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Laurie Becker-Sola 9/30/16

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Feedback

Address letters to the Executive Editor, Aviation Week & Space Technology, 1911 Fort Myer Drive, Suite 600, Arlington, Va. 22209 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.

CONTEMPLATING SUPERSONIC

As stated in "Boom Time" (*Oct. 24-Nov. 6, p. 54*), Denver-based Boom Technology found that "engine selection is the pacing item." Well, so did the Wright Brothers, who had to design and build an engine for their first successfully powered airplane.

Boom is fortunate to have some off-the-shelf power possibilities, and I look forward to Aviation Week providing updates on this project.

Steven Bezman
ALEXANDRIA, VIRGINIA

Online, comments include:

rc115shepherd **noting:**
Those who buy aircraft and use them to generate profits for their companies' shareholders have gotten control of their industry. They know what they want and what they want to do with the products they buy from the aerospace manufacturers. Those needs, so far, do not include traveling at supersonic speeds.

JD hillhouse **saying:**
If Boeing, Airbus and the airlines believe that business travelers prefer "slow," they are daft. Whoever cuts the LA-NY red-eye trip to under 3 hr. or the 14-hr. LA-Taipei trip to 5-6 hr., will find business travelers flocking to them, willing to pay for saving hours in a day, if not days.

guillaum.disayo **pointing out:**
Even without the noise issue, they would be slammed by what killed the Concorde—fuel prices. Also, the ability now to teleconference and eventually to conduct virtual meetings further diminishes the need to be in a specific place in a matter of hours. Then there is the 90 min. it takes at rush hour to get into Manhattan.

deltaflyer **waxing optimistic:**
If you don't have dreams, your dreams won't come true.

MORE THAN ONE WAY TO SEE

In relation to reader Dick Jacobson's lament about future blended wing body (BWB) airliner passengers not having access to windows (*Oct. 24-Nov. 6, p. 7*), the solution will be ready before those aircraft are certified. Virtual-reality cameras on all sides of the BWB would allow passengers with VR headsets to have the experience of looking at both sides of the ground track, flying through clouds and occasionally sharing in the thrill of a crosswind landing.

Walter Miller
SEAL BEACH, CALIFORNIA

'GUTSY' OR MISGUIDED?

"Critical Mass" (*Nov. 7-20, p. 32*) about Boeing's gutsy innovation for 777X development elicited a lot of discussion online, including:

jfcra, who **wonders:**
With robotics turning up everywhere how are people going to have jobs anymore?

jlump **responding:**
Someone still has to design, build and program the robot—and maintain it. Jobs are still there, but are different. We need to find a better way to retrain people so they can get new jobs, which are also generally better paying.

Ilya Katsnelso **offering:**
Take a look at how Germany—an industrial country with a lot of manufacturing and low unemployment rate—approached the same problem. They instituted very good apprentice programs to retrain workers.

jkdrummer **advising:**
Read the book *Rise of the Robots* by Martin Ford.

billsett1 **weighing in:**
I've been following this issue and have read *Rise of the Robots*. This is the first online comment thread I've seen where people really "get it." It's a freight train rolling down the tracks aimed straight at the economic model that's sustained global growth since WW II.

'TERM' LIMITS

I take umbrage at some phrasing in a recent editorial "Space Advice for the Next President" (*Nov. 7-20, p. 58*), to wit: "Keep NASA pointed toward Mars, bring China into the fold and don't let *climate-change deniers* kill Earth science."

Use of the word "deniers" is offensive because it is intended to bring to mind "holocaust deniers." I see it as a blatant attempt to marginalize the many scientists who question the catastrophic anthropogenic climate change hypothesis. Regardless of what one believes on the subject, a free and open discussion is central to science and to public policy. Demonizing some of the many voices in this debate is unproductive and offensive to scientists and anyone who believes in a free society.

Jack O'Leary
PLYMPTON, MASSACHUSETTS

LEANING IN

I agree with reader Mark Simmons (*Oct. 24-Nov. 6, p. 7*) about the unintended sexist comment in "Collision Course" (*Oct. 10-23, p. 18*) while referring to installations possible "by a high school girl." But as a parent with four daughters who also excelled in math and science, I should add that although installation was well within their ability as teenagers, owning the company hired to do the installations was closer to their interest.

Nat Jennings
APALACHIN, NEW YORK

POLLUTION QUESTION

What is the pollution impact of a rocket launch? The airline industry, in which I am a worker, is increasingly scrutinized for its negative contribution to pollution. Are there studies that outline what the space industry and its (increasing) rocket launches do and will do to the environment?

Riccardo Sala
TORONTO, ONTARIO

Who's Where

Bart Reijnen

Dov Sella

Ed Lundeen

Pauline Smith

Colleen Barrett

Yacob Astatke

Neel Jones Shah

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

The *U.S. Air Force* has made several general officer assignments: Maj. Gen. **Timothy G. Fay** has been named director of operations, strategic deterrence and nuclear integration for the U.S. Air Forces in Europe and Africa, Ramstein AB, Germany. Fay, who had been director of strategic plans, deputy chief of staff for strategic plans and programs at the Pentagon, replaces **Maj. Gen. John K. McMullen**, who has been named vice commander of Air Combat Command Headquarters, Joint Base Langley-Eustis, Virginia. Also, Brig. Gen. **Douglas K. Lamberth** has been named inspector general, Air Mobility Command Headquarters, Scott AFB, Illinois; he had been vice superintendent at the U.S. Air Force Academy, Colorado Springs. Brig. Gen. **Corey J. Martin** has been named U.S. senior defense official/defense attache, U.S. Embassy, Tel Aviv. He had been special assistant to the vice chief of staff at the Pentagon.

Satair Group has appointed **Bart Reijnen** (see photo) as CEO. Reijnen has held a number of Airbus Group leadership roles, most recently as senior vice president at Airbus Defense and Space, and before that was CEO of Dutch Space B.V.

RADA Electronic Industries Ltd. has promoted **Dov Sella** (see photo) to CEO from chief business development officer. He succeeds Zvi Alon, who is retiring. Before joining RADA, Sella was at Elbit Systems Ltd.

U.S. Navy Rear Adm. (lower half) **Daniel H. Fillion** has been named director of global operations, J-3, *U.S. Strategic Command*, Offutt AFB, Nebraska. Fillion had been commander of Expeditionary Strike Group 3, San Diego.

Science Applications International Corp. has named **Charles A. Mathis** executive vice president/chief financial officer.

American Airlines has appointed **Kevin Brickner** vice president for safety, regulatory compliance and environmental. He succeeds Capt. Paul Morell, who is retiring. Brickner has held several company leadership positions, most recently vice president for operations integration.

Ed Lundeen (see photo) has been named president of *Seeker Aircraft Inc.* as well as managing director of Seabird Aviation Australia. Lundeen had been business operations executive vice president for Eclipse Aerospace Inc.

U.S. industry trade organization *Airlines for America* has appointed veteran aviation counsel **Francis C. Heil** as managing director for safety. Heil has held senior positions with both American Airlines and the FAA.

Baines Simmons, an Air Partner aviation safety consultancy, has named **Jason Greenslade** and **Malcolm Rusby** as consultants. Greenslade will focus on availability, reliability and maintainability; Rusby will specialize in safety management and fatigue risk standards.

Executive AirShare has hired **John Owen** as chief financial officer. Owen had been vice president at executive search firm EFL Associates, and CFO for OrTran, a supply chain management company.

Flying Magazine has promoted **Lisa DeFrees** to associate publisher, from account manager, and **David Carr** to director of business development, from marketing manager.

Arcadis has hired **Andrew Alexander** as Seattle-based aerospace markets principal-in-charge. Alexander had led Atkins's North America aerospace sector.

Falcon Aviation in Dubai has hired **Pauline Smith** (see photo) as fixed base operations manager. She had been head of customer services and terminal manager at Marshall Aerospace.

SkyWorld Aviation has hired **Patrice Candaten** as director of sales. Candaten had been Embraer senior sales director and before that was with Saab Aircraft.

Greenwich AeroGroup's *Western Aircraft* has promoted **Jay Reeder** to turboprop regional sales manager for King Air and Cessna aircraft, and **Pat Belokas** to aircraft sales for Piper, Matrix and Archer LX aircraft, among others.

SITA has named **Klaas Fokkema** vice president for sales, Northern Europe. He had been vice president of business management for airport services in Europe.

HONORS & ELECTIONS

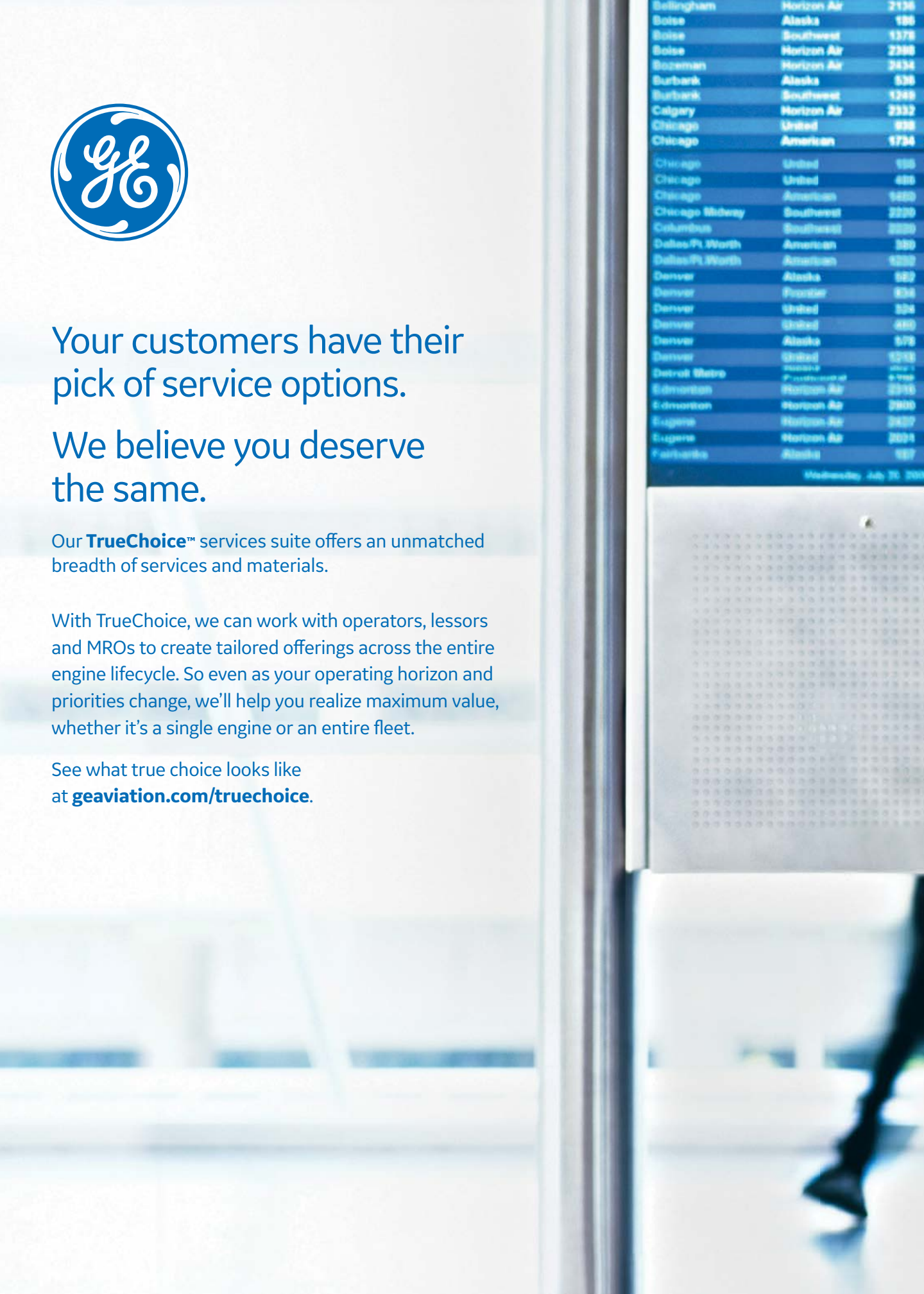
Colleen Barrett (see photo), Southwest Airlines' president emeritus, will receive the *2016 Wright Brothers Memorial Trophy* for "significant public service of enduring value to aviation in the U.S."

Airbus Group and the *Global Engineering Deans Council* (GEDC) have given **Yacob Astatke** (see photo) the 2016 GEDC Airbus Diversity Award for his work in engineering education, at a ceremony in Seoul. Astatke was chosen for his training initiatives at universities across Ethiopia.

Amerijet LLC has appointed **Neel Jones Shah** (see photo) to its board of managers. Shah has extensive experience in the global air cargo industry at United Airlines and Delta Air Lines.

The General Aviation Manufacturers Association has elected **Simon Caldecott** of Piper Aircraft as 2017 board chairman; **Phil Straub** of Garmin International as vice chairman; and **Nicolas Chabbert** of Daher Airplane as chairman of the Safety and Accident Investigation Committee.

Drone USA Inc., a manufacturer of low-altitude unmanned air vehicles, has appointed **David Y. Williams, Jr.** to its board of directors.



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First Take

GENERAL ATOMICS AERONAUTICAL SYSTEMS

DEFENSE

General Atomics Aeronautical Systems has flown the Avenger Extended Range unmanned aircraft for the first time. An increased wingspan of 76 ft. and 2,200 lb. of additional fuel extend the jet-powered UAV's endurance to 20 hr. from 15 hr.

Singapore has selected the Airbus Helicopters H225M and Boeing CH-47F to replace the fleet of a dozen AS332M Super Puma medium-lift- and CH-47D Chinook heavy-lift helicopters operated by the air force. Deliveries are to begin in 2020.

Boeing has received a $478 million U.S. Air Force contract for full-scale development of a new electronic-warfare suite for the F-15. BAE Systems was selected in 2015 to supply the all-digital Eagle Passive/Active Warning and Survivability System.

India's Rustom-2 indigenous medium-altitude, long-endurance unmanned aircraft made its first flight on Nov. 17. Designated TAPAS 201, the 4,500-lb., twin-turbodiesel, 24-hr.-endurance UAV is being developed by the Aeronautical Development Establishment with production by HAL and BEI.

DEFENSE RESEARCH AND DEVELOPMENT ORGANIZATION

Tactical Air Support is to become the world's largest private operator of Northrop F-5s after snapping up the Royal Jordanian Air Force's remaining inventory of 21 single- and dual-seat E/F models to add to its five ex-Canadian CF-5Ds (page 36).

Boeing is to cut 500 jobs over four years from its defense and space business, close two smaller plants in Texas and Virginia and transfer work to existing facilities in Southern California, St. Louis and Huntsville, Alabama, to reduce manufacturing and office space.

A UK consortium has won a contract, potentially worth £2 billion ($2.5 billion), to support avionics and other systems for the global fleet of Lockheed Martin F-35s. GKN-owned Fokker Technologies in the Netherlands and a team led by BAE Systems Australia will also support the F-35.

COMMERCIAL AVIATION

CFM Leap 1C engines on the first Comac C919 were started for the first time on Nov. 9, a step toward first flight of the Chinese narrowbody aircraft. Electrical power has been applied to the first Irtuk MC-21 as the Russian airliner heads for a first flight by March.

United Airlines is to convert its January order for 65 Boeing 737-700s into four 737-800s and 61 737 MAX aircraft, reducing expenditures by about $1.6 billion through 2018. Additionally, United will purchase, directly from Embraer, 24 175s originally ordered for Republic Airways.

Warren Buffett has long said airlines make risky investment bets, but his company Berkshire Hathaway revealed in a third-quarter filing that it has invested $797 million in American Airlines, $249 million in Delta Air Lines and $238 million in United Airlines, as well as Southwest Airlines after the quarter closed.

Straightline Aviation has signed a memorandum of understanding to operate seven Lockheed Martin LMH-1 heavy-lift hybrid airships for Canada's Rare Earth Minerals, for a shuttle service to a mining site in remote northern Quebec beginning in 2019 to transport ore, supplies and personnel.

Boom Technology unveiled an engineering mockup of the XB-1 supersonic demonstrator planned to fly in late 2017. The one-third-scale model

BOOM TECHNOLOGY

of a small supersonic airliner planned to enter service by 2023 is designed to cruise at Mach 2.2 on three J85 engines.

An Alaska Airlines 737-800 made the first commercial flight on Nov. 14 using alcohol-to-jet biofuel produced from forest residuals by Gevo with the Northwest Advanced Renewables Alliance. The fuel, made from waste limbs and branches, was used in a 20% blend with conventional fuel.

Airlines have mixed reactions to Canadian plans to change ownership rules. International companies will be able to own 49% of a Canadian airline—up from 25%—but a single foreign investor, or combination of foreign investors, will be capped at 25%.

China's Avic plans to offer a civil freighter version of the Y-20, apparently with a high-bypass engine under development for the military transport. The manufacturer displayed a cabin mockup of the 65-ton-payload civil Y20F-100 at Airshow China in Zhuhai on Nov. 1-6.

As of Nov. 9, the FAA had received more than 30,000 commercial drone registrations and 22,500 applications for remote licenses since releasing its small unmanned aircraft system rule on Aug. 29.

AEROVIRONMENT

Military small unmanned-aircraft manufacturer AeroVironment has entered the commercial drone market with the Quantix, a hybrid quadrotor that takes off vertically and transitions to wingborne flight to extend range. Deliveries begin early in 2017.

Drone delivery startup Flirtey has begun the first commercial trials of autonomous pizza delivery, flying to customers' homes from a Domino's Pizza in Whangaparaoa, north of Auckland.

BUSINESS AVIATION

Bombardier's Global 7000 ultra-long-range, ultra-large-cabin business jet completed its 2 hr. 27 min. first

BOMBARDIER

flight on Nov. 4, from Toronto. Entry into service is scheduled in the second half of 2018. The aircraft has a new wing, fly-by-wire controls and General Electric Passport engines.

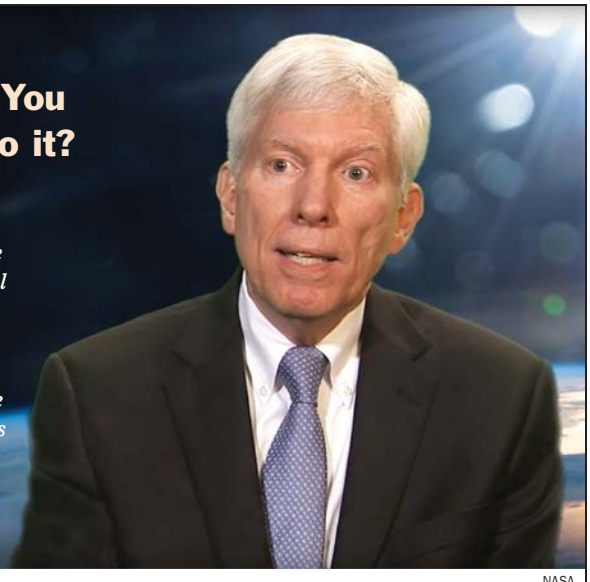
U.S. helicopter operator Erickson has filed for Chapter 11 bankruptcy protection, citing the volatility in the helicopter market, which has been hit by low oil prices. The company operates 69 helicopters supporting oil and gas, government and firefighting contracts across the world.

Avic's Chengdu fighter works is aiming for a range of 8,050 km (4,350 nm) for a proposed business jet. Dubbed the Avic New Generation Business Jet, the aircraft would have a payload of 4,900 lb. and maximum cruise speed of Mach 0.85.

QUOTED

"You may die. You still want to do it? Sign here."

— George Nield, FAA associate administrator for commercial space transportation, on the so-called informed consent model that suborbital space tourists will fly under at Blue Origin and other space access providers. The FAA licenses launches and reentries for public safety.



NASA

Bell Helicopter is preparing to support assembly of the 407GXP in China as part of a prospective sale of 100 aircraft. Partners and customers in the deal are Shaanxi Aviation Industry Development and two-year-old general aviation operator Xian Helicopter.

Customers have signed letters of intent for 17 AG600 amphibian aircraft, says its manufacturer, Avic's general-aviation unit CAIGA. First flight of the large four-turboprop flying boat is expected in the first quarter of 2017.

SPACE

SpaceX filed on Nov. 17 for approval to build a constellation of 4,425 small K_a/K_u-band spacecraft in low Earth orbit over the next decade to provide broadband internet with "full and continuous global coverage." CEO Elon Musk revealed the plan in January 2015, estimating it would take 12-15 years to complete and cost $10-15 billion.

55 YEARS AGO IN AVIATION WEEK

Our Nov. 20, 1961, cover showed North American's X-15 supersonic research aircraft over a lakebed at Edwards AFB, California, shortly after the "rocket plane" set a new speed record of Mach 6.04 at an altitude of 95,800 ft. The U.S. Air Force/Navy/NASA research program "has certainly given the United States a commanding lead in manned vehicle technology in the previously unexplored frontier between Mach 2 and Mach 6 and in the extreme ranges of altitude," Editor-in-Chief Robert Hotz wrote in an accompanying editorial. Ultimately, three X-15s would be built and make 199 flights. In October 1967, one of them achieved a speed of Mach 6.72—a record that stands to this day.

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archive.aviationweek.com

By Michael Bruno

Michael Bruno is Senior Business Editor
Join the conversation at:
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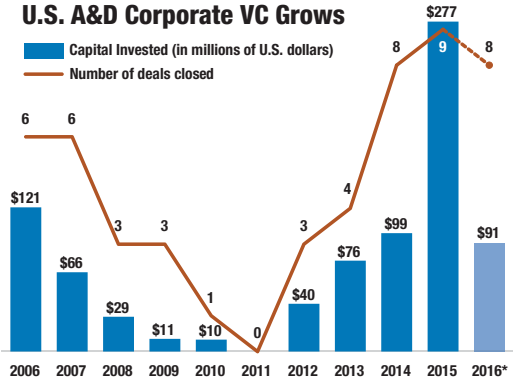
COMMENTARY

Venture Corp-ital

Stodgy old defense primes and aerospace giants are sporting new venture capital funds

Hey, startup companies: Need a little cash fast or looking to ride the Donald Trump military buildup?



**2016 figures are through the third quarter of this year, or Sept. 30.*
Source: National Venture Capital Association

Sure, you can try one of the Pentagon's new technology-acquisition offices, or press your luck in an initial public offering of stock. But increasingly there is another option to consider: prime defense contractors and aerospace OEMs.

Widely criticized as the last place to look for breakthrough innovations in recent years—remember former Boeing CEO Jim McNerney's "no more Moon shots" comment—primes and OEMs ironically are on the verge of becoming the perfect partner for startups in the aerospace and defense sector. According to several executives, large-cap companies like Lockheed Martin, Northrop Grumman and many European providers are working hard to buy their way into entrepreneurial and innovative efforts elsewhere.

Now these stodgy old primes and OEMs are increasingly launching new corporate venture capital (CVC) efforts to entice startups to work with them, with obvious benefits for all involved.

For startups, CVCs represent another funding pool to help them bridge the "valley of death"—the time between developing and proving a product or service and delivering it at scale to make money. Plus, who better to help you break into and navigate the Pentagon's roughly $300 billion annual—and reliable—buying spree than a key member of the military-industrial complex?

For the giant companies, CVCs help them scout for new technologies and capabilities for their government customers, who have become more concerned about price and affordability since the Budget Control Act of 2011 reintroduced sequestration spending caps. Also, they are concerned about losing their technological superiority as the world shifts from the Cold War paradigm where the government decided and controlled most technological advances to today's relative free-for-all in the Information Age.

"I have to recognize a lot of our technology is commercial and global [in origin], and a lot of innovations are outside our walls," says Defense Secretary Ash Carter.

He appeared Nov. 14 at the 1776 tech incubator in Washington before meeting with local startups. In that vein, Carter has pushed the department to open Defense Innovation Unit Experimental offices in Silicon Valley last year and Austin and Boston this year, and he promises more to come. But more pressing for primes is the fact that the government continues to turn directly to nontraditional providers such as SpaceX and Palantir Technologies, two Valley vets fueled by venture capitalists that, among others, are disrupting the hidebound government marketplace with great fanfare. CVC efforts are supposed to help eliminate such future shocks for legacy providers.

"Our mandate is to disrupt the mothership before someone else does," says Thomas d'Halluin, CEO and COO of Airbus Group's U.S. Venture Investments unit.

From the government-customer perspective, the legacy industry's stake in the startups also guarantees their technology or service will stick around for years or decades and not fall victim to consumer trends and life cycles. "The dinosaurs will be around for a while," jests Brett Lambert, Northrop vice president for corporate strategy and a former Pentagon industrial base policy chief.

Last but not least, it was almost inevitable that CVCs would emerge, given the wave of venture capital swamping A&D (*AW&ST* April 11-21, p. 56). Data from the National Venture Capital Association (NVCA) on U.S. A&D VC investment activity from 2006 through the third quarter of 2016 shows the annual number of deals rising steadily to at least 50 this year from 16 a decade ago. Total capital invested per year has more than doubled to $367 million at the same time.

A&D CVC activity has tracked that growth, NVCA data shows (see graph). Indeed, the percentage of yearly U.S. A&D VC deals with CVC participation looks to have made a step increase to around 16% of all deal-making starting around 2014, a level not seen since before the financial crisis of 2008.

Clearly, primes and OEMs don't want to be left out. But what are they willing to invest in? A panel of corporate venture investing leaders, including d'Halluin and Lambert, spoke Nov. 9 at the Atlantic Council in Washington and offered clues.

For starters, any investment is supposed to make money for the corporate parent—and sooner rather than later. That means something that helps a current customer's program of record, or the parent's bottom line via cost savings, for instance.

So don't expect paradigm-shifting consumer products such as iPhones from the primes or OEMs anytime soon. But make no mistake, the days of being slumbering giants rudely awakened by upstarts could be limited, too.

By Byron Callan

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

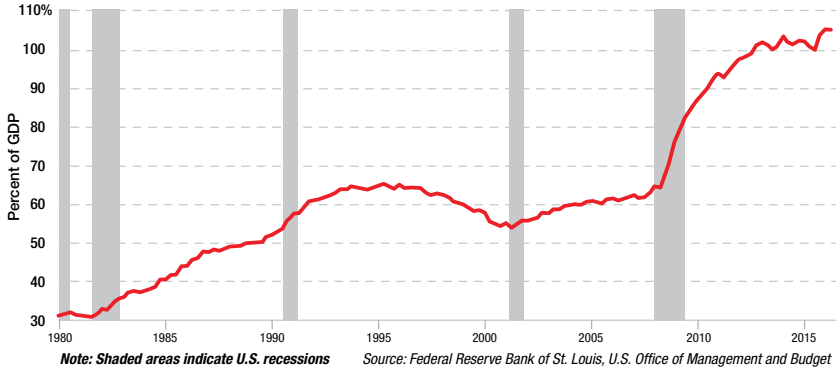
COMMENTARY

Calm Before the Storm?

How Trump's stances, Pentagon allocations and geopolitical uncertainties could roil defense in 2017

The results of the Nov. 8 U.S. election were greeted warmly by defense shareholders. From the close of trading on Election Day through Nov. 11, the largest U.S. and European companies saw their stock prices increase 8-9%. Some U.S. defense services companies, notably Engility and Vectrus, saw even higher gains, up 27% and 30%, respectively. The market response was global: The stock price of South Korean defense electronics company Victek rose 20%, and the price of Turkey's Aselsan popped 10%.

Total Public Debt as Percent of Gross Domestic Product



Note: Shaded areas indicate U.S. recessions *Source: Federal Reserve Bank of St. Louis, U.S. Office of Management and Budget*

The markets' initial conclusion that Trump will be good for defense, however, will likely be challenged by cross currents that the defense industry will have to navigate in 2017 and beyond.

The first may be the uncertainty over how much the Trump administration will want to spend on defense and what Congress will approve. The fiscal 2017 Defense Department budget submitted in the first quarter of the 2017 calendar year should provide a preliminary answer, but it will take a couple of months for Trump's national security team to finalize its fiscal 2018 budget request and plan through 2022. The growth rate should be higher than the Obama administration's plan, and the Republican-controlled Congress should be able to remove the defense caps in the Budget Control Act.

However, U.S. defense spending will still have to compete for spending resources, and some of Trump's plans could entail significant additional outlay. Initiatives to consider include the costs of deporting undocumented immigrants, construction of a wall along the border with Mexico and additional infrastructure spending. Federal debt and the deficit will also have to be factored in. Some may believe that the U.S. is on the cusp of another Reagan-era defense buildup, but the federal debt-to-GDP ratio was 32% in 1980, compared to 101% at the end of 2015.

Human capital, workers and supply-chain capacity are other issues that industry will have to navigate and that often are not appreciated by shareholders. The unemployment rate in the U.S. was 7.5-8.5% in 1981—the first year of the Reagan administration—compared to 4.9% in October 2016. Infrastructure spending, relaxed energy regulations and immigration policies may weigh on the ability of defense enterprises to readily attract new workers to implement higher production rates. Defense enterprises may want to start planning now how their workforce and supply-chain needs could change in order to mitigate risk.

Global defense markets have been a positive story for companies outside the U.S. in recent years. However, U.S. industry may need to revisit some aspects of its international strategy, and there are factors that could change the nature of the global defense trade.

Trump has called for U.S. allies to assume more of their own defense burden, and he appears willing to restore more normal relations with Russia. If these views carry through to U.S. policy, the impact on the sector could be more uneven. Other countries that increase defense spending will likely favor local industry. Additionally, a more relaxed U.S. attitude toward Russia could lead some countries to cooperate with Russia, and that may reduce their defense spending needs.

Macroeconomic factors could prove more enduring than fleeting. The initial market reaction to Trump's win and Republican retention of a majority in Congress is that more fiscal expansion is coming and with it, more federal borrowing. That will lead to higher U.S. interest rates, a further increase in the exchange rate of the U.S. dollar and other global currencies and the pummeling of some emerging ones. Higher rates may help companies fund pension plan liabilities, but a stronger U.S. dollar could make American defense products less affordable.

A final issue for the defense sector to navigate is the risk of geopolitical surprise. The Defense Business Board's recently issued report titled "Focusing a Transition: Challenges Facing the New Administration" includes a timely reminder that new U.S. administrations face "disruptive events" in the first 270 days of office from international security developments. These events can profoundly reshape defense plans, as did the Sept. 11, 2001, attacks on U.S. This is one of those known unknowns that the defense sector will have to monitor and be prepared to respond to with agility, whatever new need arises.

By William Garvey

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COMMENTARY

Show-and-Tell Time

NBAA's annual get-together highlighted a smorgasbord of new products and services

The most prominent news, such as it was, emanating from the National Business Aviation Association's (NBAA) annual convention, Nov. 1-3 in Orlando, Florida, predictably centered on the glitziest players, the airframers.

There was much ado about the recent initial delivery of the Dassault Falcon 8X; the flight-test program milestones achieved by the Gulfstream G500; the imminent first flight—since completed—of the Global 7000; and the one-day appearance of the PC-24, Pilatus Aircraft's go-everywhere light jet, expected to win certification next year. Also, Cessna brought a green Citation Longitude and announced its selection of Safran's long-delayed Silvercrest engine for the Hemisphere, its large-cabin Citation set to fly in 2019; and the lights shone brightly during the at-show certification award to the Cirrus SF-50 Vision (see photo below), the first single-engine "personal" jet to enter production.

SHOWNEWS PHOTOS

All well and good. But more than 1,000 nonairframers also set up booths to spotlight their new wares and services, and it is only fair to give an accounting or at least a sampling.

After a protracted process involving local government and private interests, **Hawthorne Aviation** announced it had completed the acquisition of Bama Air, a fixed base operation at Tuscaloosa Regional Airport in Alabama. That increases the chain's base count to five.

Wheels Up, the private aviation membership company, reported that its fleet had grown to 70 aircraft—55 King Air 350i turboprops (see photo above) and 15 Citation XLS jets—and 3,700 names on its rolls, divided among corporations and individuals. Co-founder and CEO Kenny Dichter says he expects the fleet to possibly treble within the next two years, and he will likely expand King Air operations to Europe as soon as next year.

Satcom Direct, the airborne connectivity services provider headquartered in Melbourne, Florida, revealed plans to acquire TrueNorth, a 10-year-old avionics manufacturer based in Ottawa. Satcom Direct founder and CEO Jim Jensen said the transaction should close before year-end. Just two months earlier, the company bought AircraftLogs, which makes flight-scheduling and tax-reporting software.

Aeron Corp. co-chairman Brian Barents said a popular commercial engine, which he declined to identify, has been selected for the trijet AS2. However, he noted the unit's fan will have to be reduced to satisfy technical constraints demanded by the Mach 1.5 business aircraft. While the modified engine will meet Stage 4 noise limitations, he says it is unlikely to meet Stage 5, so the goal is to complete the necessary certification work in time to have it "grandfathered" under the more restrictive level.

Inmarsat named Honeywell as the sole authorized manufacturer of hardware to access its Jet ConneX broadband satcom inflight service for business aviation. The near-global service is powered by Inmarsat's fifth-generation K_a-band satellite system. Meanwhile, Honeywell offers JetWave equipment, including modem and router hardware, with tail-mounted antenna and controller for business aircraft.

Avinode, the online air charter buying/selling marketplace, unveiled a new service for facilitating such transactions: PayNode, essentially a PayPal for the charter industry. At first, PayNode will allow customers to pay with the American Express card and eventually will accept bank wire transfers as well.

Blackhawk Modifications detailed its latest engine-upgrade program, which targets the King Air 350, replacing that aircraft's 1,050-shp PT6A-60A engines with a pair of -67As, each rated at 1,200 shp. The company expects to receive approval for the upgrade in the second quarter of 2017. The change-out will benefit those operators—including military units—looking for improved hot-and-high performance.

Jeppesen launched Operator, a new cloud-based business aviation platform that integrates flight planning, runway performance and weight-and-balance calculations, crew scheduling, accounting, pricing, regulatory compliance and trip checklists, among other things. BoldIQ, the fleet optimization and management program evolved from the failed DayJet operation is intrinsic to the new Jeppesen service.

Gogo Inc. has a way with languages. The company's inflight entertainment service, Gogo Vision, is now offering studio-licensed movies and television programs in English, French, German, Italian, Russian, Spanish and Swedish. The enhanced language capability will be available in early 2017.

Fortem Technologies Inc. of Provo, Utah, introduced its DAA-R20 radar, designed to alert pilots to the presence of small drones and "other noncooperative objects" within 600 m (1,970 ft.). The compact 1-lb. unit covers 120 deg. and can be combined with two others for full 360-deg. coverage.

Expect another round of unveilings at the next NBAA annual, set for Las Vegas Oct. 10-12, 2017.

9500

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By Jens Flottau

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COMMENTARY

Which Trump Prevails?

Next U.S. president's trade and market protection policies could affect air transport profoundly

Whether or not the looming Donald Trump presidency will mean more protectionism is the key question that airlines and aircraft manufacturers worldwide are asking ahead of the Jan. 20 transition.

FELIX GOETTING/WIKIMEDIA

Some—like Qatar Airways CEO Akbar Al Baker—are relatively relaxed: "I don't think Trump means what he says," Al Baker said earlier this year, referring to the then-candidate's statement that all Muslims should be banned from entering the U.S. Al Baker could, of course, have cited many other examples. And many months ago, Emirates Airline President Tim Clark seemed to agree, saying that ultimately Trump is "a man of business."

But which Donald Trump will we see? If the businessman and pragmatist in Trump wins out, things may not be so bad for air transport. But if the nationalist open to racist and xenophobic remarks, populism and protectionism prevails, aviation might well see a dramatic turn back to an era of slower growth, if any, and much less opportunity. The effects would be felt by airlines and manufacturers alike.

There are multiple policy areas in which a Trump administration can influence commercial aviation. Most important, how the general economy trends will be crucial for air transport, since air travel demand growth is directly linked to GDP growth. Besides that basic premise, it will be crucial for the industry to see what position Trump takes on free trade, since trends in world trade have a direct impact on air travel.

More protectionist policies worldwide have already led to sluggish international trade, and airlines feel the effect. Just ask Emirates, which has reported a 75% decline in net profit for the April-September period. Consider also the TPP (the Trans-Pacfic Partnership) and TTIP (the Trans-Atlantic Trade and Investment Partnership) that could have had a positive effect on air travel demand but are now unlikely to materialize.

The continuation of the U.S. open-skies policy and Trump's approach to other aviation-related foreign policy issues will be watched, including his views on normalizing relations with Cuba, the nuclear deal with Iran, the administration's position regarding Gulf carriers and the alleged subsidies, the proposed tight visa regime for Mexicans wanting to travel to the U.S., low-cost transatlantic air travel fostered by Norwegian Air International and the future relationship with China. There are many other issues, but these are the most important ones concerning aviation.

In an Oct. 29 opinion piece for the *Salt Lake Tribune,* Delta Air Lines former chairman Richard Anderson endorsed Hillary Clinton for president. His main argument was that her domestic economic policies were more suitable and "her commitment to innovation makes it an easy choice." Anderson did not mention trade policy, but he should have. China is one example: Delta has substantial interests there, not least because of its minority stake in China Eastern and its desire to enter into deeper cooperation with a Chinese joint venture partner. But these kinds of deals are only possible, so far at least, in an open-skies environment, which does not yet exist between China and the U.S.

How open skies will continue is also a question for transatlantic routes: The UK is leaving the European Union and will need a new bilateral air service agreement with the U.S. at some point during Trump's four-year term. What will it look like? Again, Delta has a 49% stake in Virgin Atlantic and is operating a joint venture with its partner, so it has a keen interest in the existing arrangement remaining in place.

Moreover, U.S. airlines are in the process of initiating many new routes to Cuba following President Obama's historic decision to move toward more normal relations with that country. But will the opening be reversed? Boeing and Airbus are hoping for major aircraft deals with Iran and to finally receive all the necessary approvals, but will the future U.S. government still stand behind the Iran compromise that is the basis for normalized economic ties? And finally, a significant part of U.S. international air travel is to and from one country: Mexico. Introducing strict visa requirements could have a devastating effect on demand because it makes flying a much more complex and tedious process for business and leisure travelers alike.

Donald Trump will be the first U.S. president with no previous political experience—and the first with previous airline experience: His Trump Shuttle, a high-end, domestic, short-haul carrier operating Boeing 727s geared toward business travelers in the early 1990s, folded after a few years and growing losses. It is an unthinkable model in today's era of low-cost travel. Airlines and manufacturers will have to hope that Trump learns fast, or at least appoints the right people to handle air transport policy. So far, it is anyone's guess whether that will happen.

By Graham Warwick

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COMMENTARY

Biofuel Injection

Nascent industry looks for new ways to get sustainable jet fuels to commercial scale

Finding the financing to build a new industry is the gap facing the aviation alternative fuels market. To create commercial-scale supply chains for biofuels requires investment, investors want to see customers, and customers want competitive prices, which require commercial-scale supply chains, and so it goes round.

ALASKA AIRLINES

But the circle is being broken. Airlines are buying biofuel, refineries are being built, and fuel is being delivered in commercial quantities. New mechanisms are emerging to offset the premiums on biofuels, provide airlines an incentive to buy sustainable jet fuel and bring major players into the emerging market.

Much lauded by the global aviation community, October's agreement by 191 member states of the International Civil Aviation Organization (ICAO) to launch a carbon-offsetting scheme for international aviation, called Corsia, contains provisions that could prove critical to the adoption of biofuels and the reduction of emissions.

Under Corsia, which takes effect in 2021, airlines will be able to reduce the cost of carbon offsetting if they use biofuels that have validated net reductions in greenhouse-gas emissions over their life cycle, from growing the feedstock to burning the jet fuel. The sustainable biofuels in which airlines are interested have life-cycle-analysis reductions in CO_2 of 60-80%.

Voluntary at first, offsetting under Corsia is expected to enable international aviation to achieve carbon-neutral growth from around 2024, slightly later than the goal set by industry in 2009. But biofuels will be critical to achieving the sector's next environmental target—to reduce CO_2 emissions 50% from 2005 levels by 2050. The biofuel provision in Corsia will play a key role, but the devil will be in the implementation details now being worked out at ICAO.

Issues include how to ensure one airline cannot claim credit for using biofuel purchased by another, when sustainable jet fuel will be mixed in with conventional Jet A at the fuel farm and delivered by hydrant to all carriers serving an airport. This is already happening at Los Angeles International Airport (LAX), where biofuel purchased by United Airlines under a pioneering three-year, 15-million-gal. offtake agreement with AltAir Fuels is being delivered via the hydrant system.

Sustainable jet fuel qualifies for government incentives to produce renewable fuels, but there is still a premium of $1-2 per gallon to be paid. KLM is also buying fuel from AltAir at LAX, but members of the airline's corporate biofuel program—which include major Dutch banks—are covering the price difference between renewable and conventional Jet A.

Another option is being investigated by Seattle-Tacoma International Airport with the nonprofit Carbon War Room and sustainable jet fuel distributor SkyNRG. Sea-Tac hopes to be first to supply biofuel to all airlines serving an airport, and the team is working to identify long-term financing mechanisms under which the airport would cover the price premium.

Airlines, and not airports, are the traditional buyers of fuel, so there are legal and other issues to work through, says the Carbon War Room, founded and supported by Richard Branson to accelerate greenhouse-gas emissions reductions. A precedent was set in January, the nonprofit says, when Norwegian airport operator Avinor, SkyNRG and fuel supplier Air BP provided biofuel produced by Finland's Neste to airlines flying from Oslo Gardermoen Airport under a demonstration project.

Another step toward accelerating the commercialization of alternative fuels is to involve the existing major players in the aviation fuel market. So far, the big energy companies have played little if any role, but in early November BP announced a $30 million investment in U.S.-based Fulcrum BioEnergy through its AirBP and BP Ventures businesses.

As an equity investor, BP has secured a 10-year offtake agreement for 50 million gal. a year of sustainable jet fuel for distribution by Air BP at key hubs across North America. Fulcrum produces biofuel from municipal solid waste, and both Cathay Pacific and United Airlines are already investors with 10-year agreements in place—Cathay for an initial 375 million gal. and United for up to 180 million gal. a year.

While ICAO's carbon-offset scheme will help cap emissions from international aviation, it is only a gap-filler. Continued improvements in aircraft efficiency will close some of the gap, but the industry's long-term goal of halving its emissions relies heavily on adoption of low-carbon biofuels. Now that Corsia is agreed to, there are signs the market is ready to move.

By Frank Morring, Jr.

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COMMENTARY

Coming Onboard

Detailed briefings are set for the president-elect's NASA 'artists'

Now that the Electoral College vote count has made Donald Trump the U.S. president-elect, NASA is preparing to brief its "Agency Research Team (ART)," as presidential transition teams are officially designated. Unofficially known within NASA as the "boarding party," the team will spend the next month or so perusing tablet computers provided by NASA headquarters that are chock full of what one insider terms "eye-glazing" detail on the agency's programs and plans.

NASA CONCEPT

Ultimately, the "artists"—more transition slang based on the acronym—will recommend policy changes to Trump and his senior advisors, who will also pick the administrator and other appointees to carry them out.

As the election-day dust cleared, the names of potential NASA appointees began to appear. There is an old Washington aphorism that bears repeating: "Those who know aren't saying anything, and those who don't know anything are."

Speculation aside, space usually is not very high on the priority list of incoming administrations as they lick their campaign wounds. Some of Trump's likely space-policy direction is pretty clear, based on statements by his campaign space advisors and on bipartisan legislation pending in Congress. That includes the NASA Transition Authorization Act of 2016.

Still awaiting final action, the legislation cosponsored by Sens. Ted Cruz (R-Texas) and Bill Nelson (D-Fla.) "provides stability for NASA to sustain and build upon existing national space investments." That means the senators who watch NASA and civil space do not want a repeat of the painful course change that followed Barack Obama's election eight years ago.

Trump's campaign advisors appear to agree, as far as the only word on the subject cleared by Trump Tower goes. Bob Walker, a Washington lobbyist, former House Science Committee chairman and Trump-campaign space advisor, says the incoming administration will follow the public-private approach hammered out between the Obama White House and Congress.

"Such partnerships offer not only the benefit of reduced costs, but the benefit of partners capable of thinking outside of bureaucratic structures and regulations," wrote Walker, an early advocate of private spaceflight in his Capitol Hill days, in a pre-election article.

Less clear during the campaign was the approach Trump will take on traditional NASA spaceflight developments, starting with the Orion crew capsule and the heavy-lift Space Launch System (SLS). Walker says the new administrator will definitely want to review those programs, which he says are over budget and behind schedule.

"They are awfully far along now to back off them," he says. "I think unless it is a catastrophic kind of situation they will probably continue."

A key element of the campaign's policy was reconstitution of the National Space Council at the White House.

"I'm completely supportive of the reestablishment of the National Space Council," says Mark Albrecht, who was the most recent executive director of the body during the administration of President George H.W. Bush. "There is a general consensus in the community that communitywide issues need addressing and can only be addressed at the White House level. I would welcome it."

Albrecht is said to be in line to head the space-policy portion of the Trump transition team, overseeing the ART and guiding its output. Walker stresses that he speaks only for the campaign, although he is ready and willing to help with transition space-policy issues when the time comes.

"I think there is a concern that at the time we are building the SLS, Elon Musk is building a heavy-lift vehicle, the Air Force is talking about building a heavy-lift vehicle, all with about the same capacity; and part of the reason for having a National Space Council is, as we move forward, to see to it that we do not have duplication of effort that does not make any sense," Walker says. Musk and fellow billionaire spaceflight entrepreneur Jeff Bezos have both outlined plans for SLS-class launch vehicles to move large numbers of humans off the planet.

In keeping with Republican reluctance to finance climate-change research at NASA, Walker declared for the Trump campaign that "NASA should be focused primarily on deep space activities rather than Earth-centric work that is better handled by other agencies," such as the National Oceanic and Atmospheric Administration. Although many Republican members of the U.S. space community favor a return to the Moon—a position pushed by many of NASA's international partners as well—the campaign took no position on that issue, Walker says.

Instead, it set as a goal the exploration of "the entire Solar System" with humans over the remainder of the 21st century, using that "stretch goal" to pull technology developments such as nuclear propulsion (see image) not considered seriously in the NASA "Journey to Mars" approach, Walker says.

Edited by Jen DiMascio

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COMMENTARY

The Russia Question

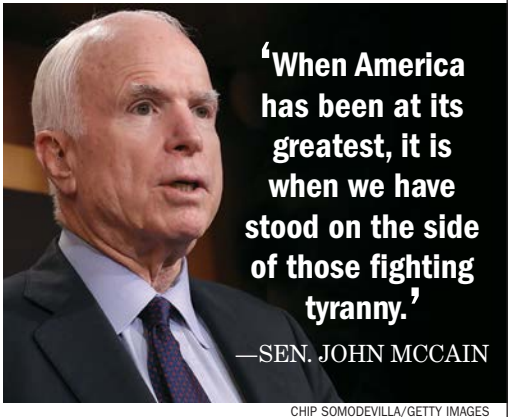
Think tank offers a view of U.S. military strengths and shortcomings

President-elect Donald Trump has vowed to "drain the swamp" of entrenched Washington interests. Creatures of D.C. have been around long enough to hear that kind of promise before. They know that after the campaign rhetoric dies down, it's time to put forward solid recommendations that might actually help guide policy.

That includes input from the conservative Heritage Foundation, which has released its 2017 Index of U.S. Military Strength. In addition to serving as an argument to bolster the think tank's perennial calls to increase the defense budget, the document is also a handy primer on global threats and how U.S. forces stack up against them.

Part of that is drawing a picture of military expansion by Russia, a country with which Trump wants "a strong and enduring relationship." Dakota Wood, senior research fellow on defense programs at Heritage, says the think tank's study lays out in great detail how the Russian military has modernized and grown in competence and confidence since it invaded Georgia when George W. Bush was president. Meanwhile, U.S. allies in Europe have underinvested in defense, Wood says. In that environment, Trump and Congress will have to decide whether it will match Russian military strength in Eastern Europe. Wood asks: "Is it important for the U.S. or not?"

Senate Armed Services Committee Chairman John McCain (R-Ariz.) still considers the defense of Europe against Russia important. He warns about Russian President Vladimir Putin's recent reciprocal olive branch to Trump. "We should place as much faith in such statements as any other made by a former KGB agent who has plunged his country into tyranny, murdered his political opponents, invaded his neighbors, threatened America's allies, and attempted to undermine America's elections," McCain says. "When America has been at its greatest, it is when we have stood on the side of those fighting tyranny. That is where we must stand again."



CHIP SOMODEVILLA/GETTY IMAGES

CHINA CARD

Republican lawmakers have long blocked NASA from bilateral cooperation in space with China, but might things change once Trump moves into the White House? Rep. John Culberson (R-Texas), chairman of the House Appropriations subcommittee that funds the U.S. space agency, is dead set against cooperation with Beijing on human-rights and national-security grounds, as was his predecessor, retired Rep. Frank Wolf (R-Va.). But one of Wolf's colleagues in the House GOP leadership, former Rep. Bob Walker (R-Pa.), takes a different view and is emerging as a potential senior space-policy advisor for Trump.

A former House Science Committee chairman and Republican floor leader, Walker says China should be invited to join the International Space Station partnership. "I think that they have become a spacefaring nation that has a lot to offer," he says, stressing that he is offering a personal view. "They are not going to learn anything about technology from being aboard the station with us that they don't already know. Having them there would allow us to share knowledge and expand the space ambitions of both nations." Walker says the question of U.S.-Chinese space cooperation was not addressed in the Trump campaign space-policy discussions he attended, nor was the longstanding U.S.-Russian space partnership.

UP AND AWAY

The number of commercial UAV pilots is booming. Since releasing its Part 107 Small Unmanned Aircraft System (UAS) rule Aug. 29, the FAA as of Nov. 9 had received more than 30,000 new-aircraft registrations from commercial operators, and more than 22,500 remote-pilot applications. A little less than half of those remote-pilot applicants—about 10,000—passed the test, says Jay Merkle, the FAA's director of systems integration and requirements analysis.

The Part 107 rule takes the place of what was previously an onerous certificate-of-authorization process for each operation. A commercial operator who obtains a remote-pilot certificate, registers the vehicle (which has to weigh less than 55 lb. but does not have to be FAA certified) and performs a preflight check. As such, that pilot can fly a single UAS with no additional permission when flown in uncontrolled airspace under 400 ft. high, slower than 80 kt., within line of sight and not over people involved in the flight. Flights beyond that kind of airspace will require a waiver.

Currently, the top five requests for waivers have been for night operations, flights over people, beyond-visual-line-of-sight (BVLOS) operations, at higher altitudes or without a visual observer, a nod to efficient BVLOS operations.

MARK WILSON/GETTY IMAGES

Now What?

Under Trump, the aerospace, defense and aviation world is guaranteed only ups and downs

Michael Bruno and Frank Morring, Jr. Washington, Jens Flottau Frankfurt and Molly McMillin Wichita

Donald Trump's election to the White House means change is coming to the aerospace and defense world, but practically no one—maybe not even the president-elect—knows exactly what those changes will be.

And that uncertainty will prevail if Trump's cries against crony government contracting are a good indication of what lies ahead, along with his promises to renegotiate many of the high-profile security and trade treaties the U.S. has signed with everyone from NATO partners to North American neighbors. His lack of familiarity with the specifics of national security, including the nuclear triad, and his criticism of Boeing's new 737 finishing facility in China add to the uncertainty.

What is known is that, no matter what degree of campaign rhetoric is turned into policy, Trump's tenure is bound to shake up a sector that simultaneously remains one of the most hidebound, government-blinded corners of business, as well as one of the world's most technologically and globally oriented industries.

How much good is achieved, or mistakes made in the process of change, remains to be seen. But one thing is sure: Like Britain's vote in June to leave the European Union, the surprise Nov. 8 U.S. election results are likely to set in motion a rollercoaster ride of puts and takes for months or years.

DEFENSE

For national security and the defense industry, Trump's victory brings mixed implications, say numerous financial and policy analysts.

"Although almost all defense contractors would likely see higher revenues if defense spending increases above current expectations, the impact on individual companies is hard to determine without more specifics on which programs will receive additional funding," S&P Global Ratings analysts say. "It's also possible that poorly performing programs could be cut to free up funds for these initiatives."

Moreover, the first defense budget that would reflect any Trump plus-up likely would be for fiscal 2019, which begins Oct. 1, 2018, so most contractors would not see any increase in revenues until 2019 or afterward. Regardless, much will depend on the next defense secretary.

In the little that is known about his approach to weapons systems, Trump has called for more missile defenses, thousands more active Army soldiers and more Navy ships, Capital Alpha Partners analyst Byron Callan notes. There are further indications of more support of Russian-derived RD-180 engines for Atlas rockets in the United Launch Alliance program for the Pentagon.

In the end, many analysts expect the Defense Department budget to grow by low-to-mid-single-digit percentages annually over the next five years. The 2011 Budget Control Act's sequestration spending caps are almost certain to be repealed, but growing federal deficits also could act as a damper on defense spending long term.

SPACE

Space-policy advisers to the nascent administration see a revived National Space Council under Vice President-elect Mike Pence, coordinating civil, military and intelligence space activities from the White House to try to avoid costly duplications. Drawing on the practice last used under President George H.W. Bush, the council would oversee all federal space activities and give the new commercial U.S. space industry a bigger role.

Trump advisors say private-sector investment could supplement government funding in heavy-lift launch and International Space Station operations. The billionaire owners of SpaceX and Blue Origin, Elon Musk and Jeff Bezos, respectively, are developing heavy-lift launch vehicles with long-term goals of colonizing the Solar System, and some Republican space experts suggest NASA's Space Launch System and Orion crew capsule are due for review by new agency managers.

Meanwhile, the Earth-science programs that have tracked global warming in the face of Republican opposition on Capitol Hill are likely to be spun off to the National Oceanic and Atmospheric Administration or other federal agencies. Theoretically, that would better focus NASA spending on advanced in-space propulsion and other technologies needed to fulfill Trump's campaign goal of human exploration of the entire Solar System by the end of the century.

"What we're saying is we ought to have another kind of stretch goal that drives us toward doing something different," says Bob Walker, a Washington lobbyist and former House Science

chairman who helped draft space-policy positions for the Trump campaign. "You can go to Mars by drifting to Mars for months. Politically and economically,, it would be much better to go there in weeks rather than months."

COMMERCIAL AVIATION

Many air transport-related lobby groups have reacted to Trump's election with optimism. Numerous trade associations—from the National Air Traffic Controllers Association to Airlines for America and American Association of Airport Executives—promised to work with a Trump administration and see opportunity for their agendas. Those items include privatizing U.S. air traffic control and airport improvements under any grander U.S. infrastructure rebuilding effort.

Taken alone, these early statements imply that civil aviation could be high on the list for Trump, who once owned a business shuttle airline serving the U.S. East Coast. But there are few indications among his statements starting almost two years ahead of the election that air transport is a top priority. While air traffic control needs modernization, the sector is not in crisis mode, and U.S. airlines are in better financial shape than they have ever been.

Thus, the new administration's effect on airlines and their suppliers is likely to be more indirect: There are many ways in which its general economic agenda can affect air transport. For instance, some Latin American currencies are being hammered in exchange markets, which is not good for local carriers locked in with a large portion of their costs in U.S. dollars.

Above all, should Trump enter one or more trade wars with other countries, especially to promote local employment and turn back globalization, air transport will suffer. A U.S. trade war or worse with China, home to future airliner order growth, could cut into Boeing's aircraft backlog.

Finally, there are conflicting interests inside the U.S., too. Boeing is keen to see Gulf carriers thrive, since they have investments lined up with multiple billions of dollars, and those airlines were key to the launch of the 777X. Open-skies policies have also been a key ingredient for U.S. airline success as carriers pushed more onto international routes in an effort to grow further despite a near-saturated domestic market.

BUSINESS AVIATION

In contrast to his stance on commercial aviation, Trump has demonstrated the importance of business aviation, which is good for the industry, says aviation consultant Rolland Vincent. The day before the Nov. 8 election, for example, Trump flew to at least five different campaign events around the U.S.—travel that would have not been possible without private aviation.

But as with commercial air transport and its supply chain, macroeconomic conditions matter more for future business aviation orders. "Bizjet OEMs have long blamed uncertainty as one of the issues that have been holding down new bizjet demand, and the uncertainty level has arguably moved up another notch," Vertical Research Partners analyst Robert Stallard says. "However, if we now see more 'pro-business' legislation in the U.S., such as tax breaks on new jets, whilst a weakening in the U.S. dollar helps the price for overseas buyers, this could help the demand set-up for the longer term, particularly as new models start to ramp."

But again, Trump brings a lot of unknowns. "What we don't know is what scares me," Vincent tells Aviation Week. "We have the potential for a reactive policy. It's intimidating because we really don't know. We don't have details on policy."

That uncertainty would make it difficult for businesses and corporations to invest in major capital projects. The rhetoric has been severe, Vincent notes, adding that still, "it may be fine."

LOOKING AHEAD

Little of this uncertainty is new, and much has been discussed about what Trump has said and what it could mean (*AW&ST* Aug 15-28, p. 51). But it is nonetheless curbing initial enthusiasm.

"While many see the election results as leading to increased U.S. defense spending, it's worth keeping in mind that the aerospace industry today is a truly global animal," says Luigi Peluso, managing director of the aerospace and defense practice at consulting company AlixPartners. "Most major players are highly dependent on international customers and suppliers just to function, including on the commercial side. So we're talking about some very, very complicated things here."

What is known is how the industry stands as the Trump team prepares to take office in January. According to the Aerospace Industries Association (AIA), the U.S. aerospace and defense industry notched a record $142 billion worth of exports in 2015. In fact, it accounted for 9% of all U.S. exports and was the nation's third-largest exporting industry. But it is not just a recent phenomenon: Exports have grown 62% from $88 billion in 2010.

Overall, industry generated a trade surplus of $81 billion last year. Since 2010, the trade surplus has increased by an annualized growth rate of 8.2%, AIA data shows.

To that effect, Boeing, the sector's single largest provider, makes for a case in point: "Trump's promise to revise U.S. trade agreements to bring jobs back to the U.S. clearly is a risk, since exports account for about two-thirds of Boeing Commercial Aircraft sales, with about 15-20% going to China, which has been willing to shift orders between Boeing and Airbus for political advantage," say Cowen and Co. analysts.

"[Trump] also may oppose continuing the U.S. Export-Import Bank, which provided financing for 11% of Boeing's sales in 2015," the analysts continue. "And the proposed sale of 80-plus airplanes to Iran may be in jeopardy if Trump scraps U.S. participation in the nuclear deal with Iran.

"On the other hand," they note, "because creating jobs is his key priority and Boeing is a leading exporter, Trump may temper his positions."

What To Watch

Defense How much will spending grow?

Security NATO's future? Relations with Russia?

Trade Will the U.S. become protectionist? The effect on the global economy?

Space The role of commercial space? Earth science versus exploration?

Air Traffic Control Privatized,"corporatized" or government-controlled?

Infrastructure Will airports benefit?

Business Aviation Will a president as fan make a difference?

Check 6 *Aviation Week editors discuss aerospace and defense in the Trump era:* **AviationWeek.com/podcast**

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While a Trump presidency is considered good for the defense industry, there are concerns about his views on European defense and NATO.

Winds of Change

After Britain's Brexit, Trump's ascendancy adds more ambiguity to Europe's politics and finance

Tony Osborne London

If there is one certainty concerning President-elect Donald Trump's foreign policy and approach to NATO, it is the uncertainty that surrounds it.

When he takes office early next year, Trump will be facing a more unstable world than his predecessor Barack Obama did eight years before.

And he will have to confront issues such as war in the Middle East and tensions in the South China Sea and relationships with key allies, particularly those in Europe unsure about his agenda.

During the campaign Trump repeatedly said that the price the U.S. pays for its place in NATO is disproportionately high and that European members need to be more willing to spend on defense.

Few would disagree with him.

And although President Obama has sought to reassure members of the alliance, some countries are beginning to wonder whether the president-elect's posturing will translate into policy.

"If there is one characteristic of a Trump foreign policy right now, it is one of uncertainty," says Matthew Harries, a research fellow on Transatlantic affairs at the London-based International Institute for Strategic Studies think tank. "We do not know which of his foreign policy [remarks] were exaggerated boasts in the heat of the campaign and which were policies of principle."

This is a "new situation," he added. "The U.S. as an actor in multilateral institutions and diplomacy will now be at least more unpredictable and likely less constructive."

In his victory speech, Trump tried to sound a conciliatory tone to calm fears, stating that under his presidency the U.S. would "get along with all other nations willing to get along with us." He noted, "While we will always put America's interests first, we will deal fairly with everyone."

But the concerns are shared by European leaders, who were cautious in welcoming the results. German Chancellor Angela Merkel said Germany's relationship with the U.S. would continue as long as it was linked by values of "democracy, freedom, respect for the rights and dignity of man." French President Francois Hollande said Trump's election had opened a period of uncertainty.

German Foreign Minister Frank-Walter Steinmeier was less diplomatic, however, suggesting that things would become "more difficult" with the election of Trump. "I think we must expect that American foreign policy will become less predictable for us, and we must expect that the United States will be more inclined to make decisions on its own," Steinmeier said.

Interestingly, none of the leaders of the Baltic States have commented on Trump's election. The president-elect is said to be ambivalent toward the Baltic NATO members bordering Russia—Estonia, Latvia and Lithuania—that fear a Crimea-style invasion by Moscow. All three currently enjoy a heavy U.S. and NATO presence.

In congratulating Trump, NATO Secretary General Jens Stoltenberg said U.S. leadership of NATO is "as important as ever" and that a strong NATO is "good for the U.S. and good for Europe."

But the optimistic language used by Moscow in welcoming Trump's election does not help. President Vladimir Putin talked about reestablishing "fully fledged relations" despite its continuing aggression on NATO's eastern frontiers and its ongoing support for the conflict in eastern Ukraine.

Britain is hoping it can continue its ongoing special relationship with its cousins over the pond, and there is no reason why it cannot be business as usual. Trump himself has significant business interests in Scotland that he is unlikely to want to endanger. But a more isolationist U.S. could give the UK a colder shoulder, leaving a post-Brexit Britain without strong ties to either the European Union or its transatlantic ally.

"Prime Minister Theresa May will have to play a clever hand to ensure that Trump remains as much of a friend to the UK as President Barack Obama," says Peter Roberts, a senior fellow at the Royal United Services Institute think tank in London. "How much a [relatively] liberal UK is willing to compromise its values and morals in order to stay at the U.S. table may be a question that needs to be addressed, and soon."

Unpredictability in policy also brings with it unpredictability in the markets and foreign exchange rates that underpin key defense programs. But this did not seem to affect the stocks of the big defense companies, which rallied as the election results were announced. The companies are keeping their views to themselves for now. While Republican governments are generally seen as good news for the defense business, and Trump himself is seen as a friend to industry, his so-called "America First" policies could cause issues. It could be that companies looking to export to the Pentagon may find the already high barriers to entry stacked even higher, or the path shut to them completely.

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F-35As Travel Abroad

U.S. Air Force squadron participation in theater security package will signal support of allies

Lara Seligman, Hill AFB, Utah

Fifteen years after the Pentagon awarded Lockheed Martin the initial contract to build the F-35 Joint Strike Fighter, the U.S. Air Force's first operational F-35A squadron is preparing for its first overseas deployment.

The "Rude Rams" 34th Fighter Sqdn. here at Hill AFB, Utah, is gearing up to participate in a so-called theater security package (TSP) next year, squadron commander Lt. Col. George Watkins tells Aviation Week. The Air Force has not yet settled on a location, but Air Combat Command (ACC) is considering a range of options, including U.S Air Forces Europe as well as Pacific Air Forces Command.

At a time when China and Russia are flexing their muscles in the Pacific and Eastern Europe, the F-35's presence abroad will signal the U.S. military's commitment to the security of its allies. The aim of the TSP is to support international treaties and train with U.S. allies, as well as demonstrate that the aircraft is capable of providing support to combatant commanders in theater, according to an ACC spokeswoman.

Sending the fifth-generation fighter across the ocean will serve not only to demonstrate its capabilities to U.S. partners but also to underscore the military's capability and willingness to retaliate against potential adversaries, top brass suggests. The Air Force will not be the first U.S. service to deploy its F-35s overseas: Marine Fighter Attack Sqdn. (VMFA) 121, the "Green Knights," based out of Marine Corps Air Station (MCAS) Yuma, Arizona, flies to MCAS Iwakuni, Japan, in January.

"I think it's a powerful signal that we are sending our very best fighter aircraft to the Indo-Asia-Pacific first, before we deploy anywhere else, and it will showcase not only American technology but also American capability," says Adm. Harry Harris, commander of U.S. Pacific Command. "There is no other aircraft on the planet that can touch it, any adversary aircraft, nothing like that will be able to touch the F-35," he says.

To prepare for the upcoming deployment, the pilots and maintainers of the 34th Fighter Sqdn. will continue honing their technical skills and processes as well as training six brand-new pilots. Meanwhile, the Rude Rams will soon take 12 F-35As to make their debut at the famous red flag training event at Nellis AFB, Nevada, an exercise that will prove the fledgling squadron's readiness for combat.

Already, airmen say the F-35A is a significant leap forward in capability from fourth-generation fighters, and many of its early technical problems seem to have been resolved. As recently as this spring, development test (DT) F-35As at Edwards AFB, California, were plagued by a glitch called 3i in the latest software load, which causes the fighter's systems to shut down and have to be rebooted—both on the ground and even in mid-flight. But Capt. Richard Palz, officer in charge with the 388th Maintenance Sqdn., says F-35 prime contractor Lockheed Martin was able to fix the issue, and the Hill-based aircraft are operating largely glitch-free.

Where DT pilots at Edwards were having trouble booting up their aircraft about once out of every three flights, Palz says the F-35s at Hill have been able to maintain an "abort rate" of less than 2%. This level of reliability is impressive, he says, particularly compared to legacy aircraft.

"I could tell you, for my F-16 unit next door—that is not the case," Palz says.

Meanwhile, the "break rate" for the Hill F-35s—how often the aircraft breaks after a flight—is just 5%, compared to about 13% for the F-16s here, Palz notes. The F-35 pilots rarely see shutdown events of the aircraft's mission systems during flight, and so far

Airmen assigned to the 34th Aircraft Maintenance Unit and 75th Logistics Readiness Sqdn. perform hot refueling operations on an F-35 Nov. 8 at Hill AFB

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there have been no instances where flights were diverted or aborted due to software glitches, he says.

One reason for the improvement is that Hill has Lockheed's most recent F-35 production build—low-rate initial production lots (LRIP) 7 and 8—while the aircraft at Edwards are from LRIP 4, an earlier F-35 build. "It's almost a different version, so we have the most mature, vetted, capable, modified aircraft in the fleet, where your Eglin and Luke [AFBs] do not," Palz says. "I couldn't do half with those aircraft what I can do with these aircraft."

In this way, the airmen of the Air Force's first operational F-35 squadron are finally seeing the benefits of so-called "concurrency"—the oft-criticized method of beginning production before completing design and testing. Now the Rude Rams can use concurrency to their advantage: The pilots and maintainers report any problems to Lockheed technicians, who then incorporate the necessary modifications into the production line much earlier than contractors could during early fielding of legacy aircraft.

"So before we rip off 1,700-plus copies of this thing, we make sure we get it right, so we only have to go back and modify maybe 200 instead of having to go back and modify the whole fleet," Palz says.

Maintainers do continue to see issues with the Autonomic Logistics Information System (ALIS), the F-35's internal logistics system—for instance, error messages when ordering spare parts, says Staff Sgt. Brandon Ewing, F-35 crew chief for the 34th Aircraft Maintenance Unit. However, airmen expect to see fewer such challenges as the system matures, he says.

"There's an automation piece and a streamlining piece for maintenance that I think will be the true beauty of the system, and quite frankly we haven't gotten to some of those areas yet," says Col. Brad Lyons, 388th Fighter Wing commander. "Again, ALIS is doing what it needs to do, it's not broken, but the elegant pieces of it, the

Drone Destroyer

Microwave technology may be the answer to the military threat from UAVs

James Drew Washington

There is no shortage of innovative ways to shoot down drones. Some companies are pitching lasers, others prefer radio-frequency disruption or, if you prefer explosions, the U.S. Army has tested Raytheon AIM-9X Sidewinder air-to-air missiles and fired course-corrected projectiles with forward-blast fragmentation warheads from a 50-mm Bushmaster cannon. But could a whole swarm be destroyed electronically with a 1-millisec. zap?

The answer may lie with the Phaser system, designed and developed by Raytheon's Albuquerque, New Mexico-based Ktech group, the same team that worked with Boeing to produce the "CHAMP" counter-electronics cruise missile for the Air Force.

There was a time when radio-controlled drones were mostly in the hands of militaries and model-aircraft hobbyists, but now anybody, including terrorists, can purchase relatively sophisticated and inexpensive unmanned aircraft systems (UAS) online. Although UAS were once feared for their spying potential, there have been several accounts of self-proclaimed Islamic State group militants in Iraq and Syria using them as flying improvised explosive devices.

Finding agile, inexpensive ways to destroy these threats has become a priority for the Pentagon in recent years, and in response, Raytheon has turned its high-power microwave (HPM) technology skyward.

On Nov. 10, the company provided Aviation Week with footage of its deployable, ground-based Phaser knocking out two small drones during a 2013 experiment at the Army Fires Center of Excellence at Fort Sill, Oklahoma. The Defense Department cleared the video footage of the live-fire demonstration for public release on Oct. 5, but some details such as its effective range remain classified.

The technology is not known to have been fielded operationally, although several initiatives are underway to transition the technology to programs of record. Raytheon lifted the veil on its Fort Sill experiment during a media roundtable in Washington in June, saying the trailer-mounted device is effective against drone swarms over a wide area, has been proven to stop cars and vehicles and could even throw off missiles guided by electronics. Unlike lasers, these types of HPM weapons can disrupt or destroy electronic devices across a wide area.

Fort Sill is home to the Army Field Artillery School and is leading the development of directed-energy doctrine for the service. It conducted a live-fire investigation of the Raytheon-built weapon from Sept. 30 to Oct. 3, using it to bring down a Tier I Flanker and Tier II Tempest drone.

The HPM weapon is mounted on a 20-ft. trailer with power provided by an internal diesel generator. The Phaser system can detect and track threats using its own radar or be cued by third-party sensors. The device's parameters can be set to "disrupt" or "damage." In this demonstration, the Flanker and Tempest drones were detected, tracked and cued for destruction by a three-dimensional X-band Thales/Raytheon MPQ-64 Sentinel radar and vehicle-mounted K_u-band Close Combat Tactical Radar, with Raytheon's radio-linked Command View-Tactical system providing command and control.

"The objectives of this investigation were to engage real targets with a deployable directed-energy system, attack more than one type of threat, engage multiple threats simultaneously and kill these threats at operational ranges," the video's narrator says. "The Phaser system engaged and shot down two types of UAS targets. Both engagements took place at the speed of light, and target kill confirmation was immediate."

In June, Raytheon's Albuquerque site director, Steve Downie, said the Phaser demonstrated multiple kills in a single shot over the target area, as opposed to a laser, which must narrow in on a single point until the air vehicle is burned out of the sky. Anything that flies through the HPM's beam will be destroyed, he says.

style points, are still slowly coming in."

As ALIS and maintenance processes evolve, airmen here expect the F-35 to be a logistics game changer. The fifth-generation fighter presents opportunities to fundamentally improve the way maintenance crews support aircraft squadrons, says Lt. Col. Steven Anderson, 388th Maintenance Group deputy commander.

"We took a fifth-generation platform and dropped it into a very fourth-generation operational construct, and we're taking the opportunity to [ask]: 'What can a fifth-generation do in the way we're going to employ it, maintain it and support it, that is different from the way our fourth-generation structure is set up?'" he says. "Can we turn it between sorties a different way? Can we load it differently?"

The capabilities of the F-35 are also forcing the airmen here to look differently at the way they traditionally conduct training. The Air Force's test ranges aren't large enough, and the simulated threats aren't realistic enough, to really test the limits of the fifth-generation aircraft, says squadron commander Watkins.

During a recent exercise at Mountain Home AFB, Idaho, for instance, the F-35 pilots wanted to practice evading surface-to-air threats. But the mission proved too easy because no one on the ground could track the aircraft, Watkins says. The pilots resorted to flipping on their transponders, used for FAA identification, so simulated anti-aircraft weapons could track their movements and actually present a challenge.

"It's such a leap in technology and a leap in capability that you can't treat it like a fourth-generation platform," says Lyons. "We need to go with a blank sheet of paper."

The Rude Rams will get the final 3F software configuration, which will give the F-35 full warfighting capability—including the ability to load external weapons—sometime in late 2017, says Anderson. Ultimately, the 388th Fighter Wing will stand up three F-35A squadrons, a total of 78 F-35As by the end of 2019.

Because the HPM weapons do not discriminate between friendly or enemy electronics, extra care must be taken to avoid wrecking your own systems. But the technology shows promise for fixed-base protection or to destroy airborne threats on the move as part of a convoy. Raytheon says it has halved the size of the Phaser payload since the experiment in 2013 and believes it can deliver an operational system with 18 months of a contract award and could build 5-10 units per year at its Albuquerque site.

U.S. ARMY VIA RAYTHEON

Raytheon's Phaser weapon can destroy whole swarms of drones with a single burst of microwave energy.

"The effect from a high-power microwave is not instantaneous but certainly [evident] within milliseconds," Downie says. "A laser is typically going to focus on a target for seconds to kill it. If you're addressing a swarm, an HPM is going to put out a field and anything that flies through that field is going to go down. Once you're invested in the cost of the system, it costs cents per firing. It is negligible compared to a missile. This technology really does exist."

The Air Force was among the first to build an operational microwave weapon, the non-lethal, vehicle-mounted Active Denial System or "Pain Ray" that was deployed to Afghanistan to disperse crowds or force people to drop their weapons by causing a burning sensation under their skin. In 2012, Boeing and Raytheon successfully flight-demonstrated their cruise-missile-based HPM weapon under the Counter-electronics High-powered Microwave Advanced Missile Project, or CHAMP, experiment, launching one from a B-52H bomber to destroy electronics at the Utah Test and Training Range. Three of those weapons were built, and Raytheon has been put on contract to refurbish two unexpended rounds as test and training assets.

Meanwhile, the Air Force and Navy are now embarking on another demonstration effort, led by the Air Force Research Laboratory's directed-energy division at Kirtland AFB in New Mexico. That program, dubbed High-power Joint Electromagnetic Non-Kinetic Strike or HiJENKS, will probably explore a more operationally relevant version of the CHAMP weapon based on a modern cruise missile instead of the outdated AGM-86C Conventional Air-Launched Cruise Missile, with flight testing expected around 2018-19, based on available funding.

Directed-energy proponent Mark Gunzinger, of the Center for Strategic and Budgetary Assessments, says the government needs to do a better job transitioning successful experiments into operational weapons systems. Examples of missed opportunities include CHAMP and the Boeing X-51 WaveRider, a hypersonic missile prototype. He has called on the incoming Trump administration to more quickly move directed-energy and electronic-warfare systems from the laboratory into programs of record, particularly for defending U.S. forces and bases from air and missile threats.

"The new administration needs to begin to transition new, mature technologies to acquisition programs rather than continue to fund a seemingly endless series of experiments and demonstrations," Gunzinger tells Aviation Week.

Video *Watch Raytheon's swarm-destroying HPM technology demonstration:* **AviationWeek.com/Phaser**

Record Ramp

CFM assembly sites poised for unprecedented production increase as Leap engine rates rise

Guy Norris Lafayette, Indiana

The quiet atmosphere and open spaces of General Electric's newly opened facility—dedicated to CFM Leap assembly—at Lafayette, Indiana, belies the massive scale of the industrial buildup about to burst forth as engine production accelerates for both the Airbus A320neo and Boeing 737 MAX.

Although preparations for this momentous ramp-up have been underway for at least five years, the sheer scale of the production challenge facing CFM joint venture partners GE and Safran is beyond anything predicted when the program began. With orders for 1,554 Leap and 855 CFM56 engines taken so far in 2016 alone, CFM's backlog exceeds 14,000 units representing eight years of production.

CFM

The Lafayette site began assembly of Leap 1A cores (right) and complete Leap 1B engines earlier this year.

The first signs of the coming tidal wave of Leap engines can be seen at Lafayette, where GE has begun making the first Leap 1B production engines for the MAX. The first units produced here, and by GE's sister Leap production line in Durham, North Carolina, are now at the company's Peebles, Ohio, facility for predelivery testing.

Having delivered 50 Leap 1A engines to Airbus for its growing A320neo fleet, plus a handful of engines for 737 MAX testing, CFM says it is on track to deliver more than 100 Leap 1A/B engines this year and over 500 in 2017. However, the rate will sharply increase, with approximately 1,100 Leap engines slated to be delivered in 2018. Beyond that point, the rate begins to ease as it passes the 1,900-engines-per-year mark in 2019 and to steady at an anticipated 2,000 per year in 2020.

"So there are about 14,000 engines in the backlog between CFM56 and Leap—that's quite a big number and there is a lot to do still," says Cristina Seda-Hoelle, Leap manufacturing program director for GE. "We can't forget the CFM56; it's a record production year for that," she adds, noting that about 1,600 CFM56s will be delivered in 2016, from a backlog of over 2,500.

The scale of the ramp-up of the Leap and the transition at full-rate from the CFM56 between now and 2020 "keeps us up at night, I'll be honest with you," says Seda-Hoelle. "The volumes we hit on CFM56 took us 20 years to get to, and we have do that in four years on Leap. It is a CFM56 replacement, but it has new technologies, a complicated supply chain, a lot more externals—it's a different engine. We think of it often as a baby GEnx," she adds, referring to the similarities of the Leap configuration to the larger powerplant developed by GE for the Boeing 787 and 747-8.

"So it's a scary, daunting ramp, but that is what focused us on doing something different with the supply chain this time. We know we must deliver," she says. Differences from the tack taken with the CFM56 include a parallel technology readiness level/manufacturing readiness level development approach. "It's a very regimented approach with toll gates [that] take the part from the design phase all the way to the highest levels of production," says Seda-Hoelle.

"We don't do it on every part, and we only pick certain key technologies above and beyond parts like the composite blade, ceramic shroud and additively manufactured fuel nozzle." The most complex parts, which number about 30, have been built in the company's lean labs to make sure that "when these parts hit production they can make rate," she adds.

About 75% of the Leap parts are outsourced from the GE side. "Early on, we set the stage for anyone who wanted to participate in the Leap program. They had to go through some pretty rigorous self- and on-site assessments with our sourcing team [just to] bid on Leap," says Seda-Hoelle. "We assessed their capabilities and capacity and said, 'Look, if you want a ticket to the game you've got be ready, and we want to see it first-hand,' so we've [conducted many] on-site assessments."

However, as the recent experience of Pratt & Whitney's ramp-up issues for the geared turbofan shows, unexpected challenges can thwart the best-laid plans. Supply chain hurdles may crop up with new technology areas or, because of the sheer volumes, with "something relatively mundane like forgings and castings," says AeroDynamic Advisory President Kevin Michaels. "Could we be in for a surprise there? Not everyone may have capitalized for that type of production rate," he adds. "I'm just raising a yellow flag on the part of the subtiers."

To maintain a watch on supply chain status, GE's CFM sourcing team visits suppliers often. "We have some SWAT (special weapons and tactics) team resources we have put in place too, to make sure that as we see issues come up we can address them," Seda-Hoelle adds. Digital tools are also employed to


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help CFM independently verify work-in-process (WIP) in the supply chain.

CFM is also dual sourcing and, in the case of some parts, triple sourcing up to 80% of the Leap. "We have done that for reasons of business continuity. You've got to have a back-up plan because of the sheer capacity needed. It's been quite a challenge, and we are on track," Seda-Hoelle says. She notes that most of the dual sources will be in place by the end of 2017, although some will be done ahead of that schedule because it suits the plan to pull them in earlier.

This year, suppliers are also being included in CFM's "run-rate" process, which simulates the higher production rates of the coming months and years. The protocol, first tested in 2015 at Safran's recently opened Leap fan blade and casing facility in Rochester, New Hampshire, evaluates the manufacturing process in a safe environment and ensures confidence in the ability of the system to hit the rates that are coming later.

"Right now, we are testing rates for the fourth quarter in 2017," Seda-Hoelle says. "This covers everything from raw materials to inspection at the end of the line to see what breaks in the process." The stress testing, which involves about 60 GE and Safran suppliers, can run 2-12 weeks, depending on the lead time of the part. "We are running 12 sets per week for two weeks now," she adds.

SHIFTING FOCUS

Thierry Dubois Lyon

Reducing production costs is Safran Aircraft Engines' new focus in the CFM Leap engine program, as the 1A and 1B versions of the turbofan have been certified (in November 2016 and May 2016, respectively) and after the 1A entered service in August. The shift in priorities signals the program's entry into a new phase, with the production challenge being no smaller than the development effort.

Safran quietly launched an in-house cost-reduction program for the Leap and in July extended it to its suppliers. The initiative, dubbed "Leap Together," is seeking ideas to cut costs at every level of the supply chain, as well as on the assembly line. "We're ready and willing to help [our suppliers], and support their own initiatives through cross-fertilization, by sharing best practices and using the same levers," says Safran Aircraft Engines CEO Olivier Andries.

At least Safran and CFM partner GE can deal with the two endeavors in sequence, while competitor Pratt & Whitney is grappling simultaneously with technical issues and ramp-up delays.

Safran already had planned on a 40% reduction of production costs for Leap in 2016-20. This will occur thanks to the expected learning curve, the volume factor and better use of double-sourcing, meaning buying more from lower-cost suppliers. Leap Together is aimed at reducing production costs by another 15% over the same period.

So when did Safran decide to launch Leap Together? "It came rather naturally when entering this period of financial transition, after the end of the development phase; it is the right time to do it," Andries tells Aviation Week.

In terms of Safran's financial results, the Leap program is anticipated to have a negative impact for years before the investment pays off. The contribution of the combined CFM programs (production ramp-up of the Leap and decrease of the CFM56) to Safran's gross margin is expected to start significantly decreasing this year. It is then predicted to hit zero in 2018, rebounding in 2019 before it increases—the hope is sharply—from 2020.

More than 150 companies supply parts that account for two-thirds of the cost of a Leap turbofan. "With our suppliers, we will have hundreds of ideas—[though] they won't all have the same impact," Andries says.

Inspections are one area where costs could be reduced. "Inspection costs are important in the total cost and the production cycle of a part," he points out. Also, manufacturing requires numerous steps and some may eventually be deemed useless, or its added value insufficient. Transportation costs could also be cut.

In some cases, it may also be worth investing in changing the design of parts, Andries explains. "We will not hesitate to redesign a part if it allows [us] to reduce costs," he adds. Other cost-saving ideas may involve recycling more materials on the production line.

The backlog for the Leap is much greater than initially forecast—by 50%, according to Safran. CFM has received some 11,500 orders and commitments for the Leap's three versions—the 1A on the Airbus A320neo, the 1B on the Boeing 737 MAX and the 1C on the Comac C919. Therefore, the company believes the situation is comfortable enough to give it some leverage with suppliers in upcoming price talks.

Safran has always warned that ramping up Leap production will be a daunting task. "In just four years, we will achieve a Leap production rate higher than the current rate for the CFM56—a rate that took us 35 years to reach," Andries says. To underline the difficulty of the challenge, Pratt & Whitney—another leading engine manufacturer—is also experiencing problems in the early production stages of its competing PW1100G.

So how confident is Andries about keeping promises made for Leap output in the coming years? "The challenge is real," he admits. "We estimate we have a number of assets on our side that make us confident. I do not want to be arrogant; it will be a marathon until 2020."

About 60 Safran employees monitor the supply chain. "As we speak, we are doing well, as our deliveries to Airbus are meeting their needs," Andries says. Although the Leap Together cost-reduction plan is purely a Safran-led initiative, information about it has been shared with GE.

Launching such a cost-cutting effort means that Safran is "super-confident in its supply chain," an industry analyst notes. The plan is ambitious and is great news for Safran as well as Airbus and Boeing, he adds. Since the beginning of the A320neo and 737 MAX programs, both airframers have been demanding cost reductions from their suppliers.

Stretching the Market

Airbus and Boeing are considering even larger versions of twinjets

Jens Flottau Frankfurt and Guy Norris Los Angeles

Airbus and Boeing appear to be moving closer to defining additional stretch versions of their big A350 and 777X twinjets, prospects for which were raised by both manufacturers earlier this year.

If the plans come to fruition, the aircraft could grow to well beyond 400 seats in some of the more dense airline configurations. The fact that such an initiative is being considered shows how far twin widebody aircraft are advancing into the ultra-high-capacity markets that have previously been the exclusive territory of four-engine aircraft such as the Boeing 747 and Airbus A380.

If launched, the new large twins would make it even harder for Boeing to sustain production of the 747-8 over a longer period of time, in spite of recent freighter orders. And while the size gap between the proposed 777-10X and the A350-2000 on the one hand and the A380 on the other is more significant, their availability could sway carriers that have considered orders for the Airbus quad to remain conservative as more suitable alternatives—even for big hub markets—are becoming available.

The potential launch of a larger A350 could create the first application opportunity for Rolls-Royce's Advance engine initiative.

Airbus has been considering a further A350 stretch for around two years. The rationale behind that move would be the ability to offer a version similar in size to the 777-9X, which can seat around 400 passengers. The A350-1000 is about 30 seats smaller in typical airline configurations and matches the capacity of the current 777-300ER, but the proposed -2000 would be superseded again in size by the proposed 777-10X if that version is launched.

Both manufacturers are pitching the proposed aircraft to Singapore Airlines, among others. Airbus has been arguing that Boeing went up in capacity for the -9X to drive down unit costs but said it was unclear whether airlines actually needed the additional capacity in that market segment. Airbus CEO Fabrice Bregier said last summer that he was concerned the proposed -2000 could cannibalize sales of the -1000.

However, should Boeing stretch the 777X again, Airbus would presumably have to counter with a larger A350 to offer a similar range of products.

Entry-into-service timing also remains unclear. Unlike Boeing, Airbus could bring its new largest twin to market relatively quickly, as it is nearing the end of its current development cycle, which includes the A320neo family and the two smaller versions of the A350. Boeing, in contrast, still has its hands full finalizing development of the 737 MAX family and ramping up 777X work. The U.S. manufacturer also has to weigh the impact of its potential new-midsize airplane, which may compete for development resources with another 777X derivative, although the added version would require much less work.

The exact timing will likely have a major influence on Airbus's choice of an engine. The A350-900 and -1000 are powered by versions of the Rolls-Royce Trent XWB, the largest of which is the XWB-97, at 97,000 lb. Although Bregier has indicated he would prefer a relatively simple and small stretch of the A350 beyond the -1000, a more powerful version of the engine is almost certainly needed. The A350 already has a complicated engine history: Airbus and Rolls-Royce were forced by key customers such as Qatar Airways and Emirates to beef up the XWB-97 because Gulf carriers at the time were concerned about an earlier proposal's performance limitations. Qatar stuck to its order, but Emirates backed off from its commitment in 2014, unconvinced by the changes.

Singapore Airlines CEO Goh Choon Phong (right) talks with Airbus Executive Vice President of Programs Didier Evrard (center) and Rolls-Royce Civil Aerospace President Eric Schulz. The airline may launch a stretched version of the A350.

If Airbus prolongs a decision, the A350-2000 could be the first application for Rolls-Royce's Advance program, the new baseline architecture that supersedes all the engines that have been based on the RB.211—including the Trent family.

The Advance engine is targeted primarily at the next step-change in thermodynamic efficiency and will be built around a new high-pressure core with a pressure ratio at or above 60:1. The new core provides the foundation of a potential new turbofan family in its own right, as well as a stepping-stone to a follow-on engine called the UltraFan. Advance will have a bypass ratio in excess of 11:1 and a fuel burn at least 20% better than the current Trent 700 when it enters service around the end of the decade.

Talks about the proposed -2000 and the 777-10X have intensified with several airlines this year, notably Asian carriers. Among those that have expressed interest publicly in an even larger A350 is Cathay Pacific.

Boeing confirmed studies of a 777-10X stretch at this summer's Farnborough Airshow.

Boeing is on track to complete engineering release of the 406-passenger 777-9X, which is the first and, so far, largest planned member of the new 777X family, by mid-2017. The -9X is slated to enter service in 2020, and its shorter, 355-passenger 777-8X stablemate will follow in 2022.

At 251 ft. long, the 777-9X already edges out the 747-8 as the world's longest airliner, but a further stretch would ensure the 777X's status as the largest twinjet ever developed. According to CNN, the larger 777X variant would be extended by a further 12 ft. to around 263 ft. in length overall. The current 777-300ER is 242 ft. long; the rival A350-1000 is some 237 ft. in length overall.

Pushing Back

China's two space launcher builders are increasingly in competition

Bradley Perrett Zhuhai, China

Casic is not taking this lying down. Faced with an invasion of its solid-propellant turf by sibling state group CASC, the Chinese defense and space contractor is preparing a medium-capacity launcher that could take business from its rival. Casic is also moving into liquid-propellant technology, another domain of CASC.

It is already well into development of a solid-propellant launcher that would compete closely with CASC's Long March 6. The new Casic launcher, KZ-11, will fly in December or soon after, say officials of the state manufacturer.

Displayed in model form at Airshow China, held here Nov. 1–6, KZ-11 can hurl 1 metric ton (2,200 lb.) to a 700-km (430-mi.) sun-synchronous orbit, Casic says. That is exactly the same as the capability CASC attributed last year to Long March 6, although that new liquid-propellant launcher has also been credited with a payload in the 500 kg (1,100-lb.) class.

Casic has a smaller solid-propellant launcher, KZ-1, of which the current version is KZ-1A, capable of delivering 300 kg to an unstated orbit. KZ-1, which flew in 2013, could place 300 kg in a sun-synchronous orbit, media have reported. Some systems are shared between KZ-1 and KZ-11, Casic officials say.

Exploiting its inherent ease of handling as a solid-propellant rocket, KZ-11 can be carried and fired by a transporter-erector-launcher (TEL) vehicle, as can KZ-1. It can therefore be fired from any clear site, say the officials. That contrasts it with the dependence on elaborate fixed-launch facilities of CASC's liquid-propellant launchers.

BRADLEY PERRETT/AW&ST

The "model" of the CASC methane-burning reusable rocket engine displayed at Airshow China in Zhuhai.

Mobility is militarily useful, since an enemy can destroy fixed facilities. Moreover, it offers the possibility of hiding the launcher, though an official drawing of the KZ-11 on its TEL depicts an enormous assemblage that would require wide roads with long-radius curves.

A second advantage of solid propellants is a short reaction time. Casic presents this as valuable for quickly surveying the scene of a natural disaster such as an earthquake, but the Chinese armed forces likely are interested in a launcher they can use to quickly loft satellites in response to a changing military situation.

KZ-1 has been launched with a week's notice, but the response time will be cut to 2 hr., officials say. The letters of the designation are an abbreviation of the Mandarin Chinese name, Kuai Zhou, meaning "rapid vessel." Confusingly, the same name has been used for satellites that KZ-1 has lofted.

In the intertwined Chinese space and weapons-systems industry, Casic and CASC have long concentrated on complementary rather than overlapping specialties. Casic, primarily a weapons-maker, has concentrated on small space launchers that use the solid-propellant technology from missile systems. CASC, mostly a space contractor with a sideline in weapons, has built China's big rockets, all with liquid propellant. For decades, these have been the Long March 2, 3 and 4 series, using hydrazine fuel and derived ultimately from early ballistic-missile technology. Last year, CASC introduced a family of kerosene-fueled launchers, the last and largest member of which, Long March 5, flew on Nov. 3.

But CASC also moved into the solid-pro-

pellant business last year when it launched the first Long March 11. The group said Long March 11, of 2 m (6.6-ft.) diameter, had the largest solid-propellant motor so far developed in China. That cannot have been comfortable news for Casic.

Technical preparation to make solid-propellant boosters for the proposed Long March 9 Moon rocket has probably prompted CASC to develop this form of propulsion. This year, CASC ground-tested a multisegment solid motor of 3-m diameter (*AW&ST* Aug. 29-Sept. 11, p. 41).

Casic's response may be lagging, but it is not finished yet. Looking beyond KZ-11, the group is planning a solid-propellant launcher capable of hurling 10 metric tons to low Earth orbit, officials say. That would be a competitor to the Long March 7, a member of CASC's new family with a low-orbit throw weight of 13.5 metric tons. KZ-11's capacity may be differentiated from Long March 7 just enough to avoid censure from higher levels of the government. But it would be a very close competitor to older CASC launchers such as Long March 2F. Long March 7 first flew in June. CASC expects it to be the workhorse rocket of the Chinese space program.

As to CASC's liquid-propellant territory, Casic officials say they are working on the technology with a view to starting out with a small launcher. Preliminary research has begun, they add, without disclosing the propellant they are working on.

Meanwhile, CASC is pushing ahead with the wide-ranging effort on new engines and launchers that it described four years ago. (*AW&ST* March 12, 2012, p. 32). Included in this initiative is a reusable rocket engine that burns methane with liquid oxygen.

BRADLEY PERRETT/AW&ST

One-third scale models of KZ-1A (front) and KZ-11 at Airshow China.

The engine has a thrust of 60 metric tons, presumably at sea level, according to a brochure issued at Airshow China. Thrust in a vacuum is 79 metric tons.

"The engine is designed to be used 50 times," says CASC. "Its main specifications reach the level of comparable foreign liquid-fueled engines." The engine can be relit and throttled through a wide thrust range, says the group.

At the show, CASC exhibited what an official called a model of the engine. The "model," unusually, was built of metal. Moreover, it and a photograph of the engine in the brochure resembled CASC's YF-77 hydrogen-fueled engine. CASC said in 2013 that it had adapted a YF-77 to test methane technology.

Like the YF-77, the methane engine drives its pumps with an arrangement called the gas-generator cycle, which involves some loss of propellant without combustion. The choice brings the "advantages of simple structure, high reliability and convenient maintenance," CASC says.

The YF-77, with a sea-level thrust of 70 metric tons, flew for the first time as the first-stage core engine of Long March 5.

The methane-engine program is still developmental. CASC will work on improving the system's reusability, says China National Radio. Aviation Week first reported in 2012 that CASC had foreshadowed a methane engine as one of a range of products for "quick response, small size, low cost and high reliability." Rapid launching is one of the features claimed now for the methane engine, along with real-time fault diagnosis. Quick response has become a distinct theme in Chinese space-launch development over the past few years.

The methane engine can be applied to a reusable launch vehicle and for upper stages, including those that may be used for deep space exploration, says CASC.

Methane "is definitely going to be an option for the future launch vehicle propulsion," Zhang Nan, president of the Beijing Aerospace Propulsion Institute, told a meeting of the International Astronautical Congress in Beijing in September 2013. A month later, CASC said it had for the first time conducted a hot test of a methane-fueled propulsion system.

CASC's full name is China Aerospace Science and Technology Corp.

Make or Break

Webb telescope will carry grapple targets, but chances they will be used are slim

Frank Morring, Jr. Goddard Space Flight Center

NASA has no plans to service the $8.7 billion James Webb Space Telescope (JWST), but has not completely closed the door on the idea as it prepares a rigorous series of tests designed to ensure that in-space repairs will not be needed.

When the 6.5-m (21-ft.) telescope launches to the Sun-Earth Lagrange point (L2) in 2018, its launch interface ring will carry optical targets that could be sought out by a service robot's mechanized vision as it approaches to attach itself in order to make repairs.

There are no plans to use the targets. Unlike the Hubble Space Telescope, which was designed for hands-on servicing by space shuttle astronauts, the JWST is built to go through its complex deployment sequence perfectly the first time, and to perform its groundbreaking science without repairs or upgrades.

"There were brief discussions back in 1997 when the mission was being architected, but we quickly came to the conclusion that servicing was not practical," says Eric Smith, JWST program director. "Other than the decision to put optical targets on the launch vehicle adapter ring, there has been no further discussion of circumstances that would lead NASA to consider servicing."

The business end of the telescope is now complete, keeping it on track for launch in October 2018, mission managers say. That will allow the observatory to begin groundbreaking science, including cooperative observations with the Hubble, about six months after that.

"What you see behind us represents 15 years of designing and building hardware," said Bill Ochs, NASA's JWST project manager at Goddard, as he presented the telescope's Optical Telescope Element and Integrated Science Instrument Module at a press conference overlooking the huge clean room where the 6.5-m observatory was integrated.

Next up will be acoustic and vibration testing in Goddard's facilities—followed by a trip to Johnson Space Center on a C-5 Galaxy military transport aircraft—for thermal vacuum testing in a huge chamber originally built for the Apollo spacecraft that landed humans on the Moon.

In parallel, Northrop Grumman will be completing the mission's Spacecraft Element—its housekeeping bus and the five-layer sunshield that will keep it chilled to about 45K (−380F) for infrared observations. As large as a tennis court, the roughly trapezoidal structure will shade the telescope and its sensors from sunlight at L2, 1 million mi. past Earth from the Sun.

Testing of the full spacecraft at ambient temperatures will follow at Northrop Grumman. The telescope will travel by ship from California to the European spaceport near Kourou, French Guiana, for launching on an Ariane 5.

Ochs says the project remains on schedule and budget, at a total cost of $8.7 billion. The program was restructured in 2011 after a congressionally mandated study found it over budget and behind schedule, in part because of the difficulty developing the advanced instrument technologies needed to make it work as planned (*AW&ST* April 23, 2012, p. 36).

The telescope will be folded and refolded to fit its 22-m-long sunshield and 6.5-m mirror inside the launch vehicle's fairing, which is 4.57 m in diameter and 16.19 m long inside. Unfolding it will require what Ochs calls "two-and-a-half-weeks of high anxiety," in a hat-tip to the "seven min. of terror" that put the Curiosity rover on the surface of Mars.

First out will be the solar arrays, followed by the telemetry dish. After a pause to allow water vapor to outgas, the sunshield and its support structure will unfold and separate into its five-layer thermal barrier. The 18-segment mirror will launch with its two outer "wings" folded in; folding them out to form the primary light-gathering structure will follow.

"Out of the 180 or so deployments, there are probably, maybe, a half dozen or so that if they didn't work, we could probably adjust to and live with," says Ochs. "For the most part, it all has to work."

The JWST engineering team is developing canned sequences to troubleshoot and fix any snags that arise along the way "so you're not spending days trying to solve the problems," Ochs says. If something insurmountable happens that renders the telescope useless, the optical targets on the ring that holds the spacecraft to the launch vehicle will certainly become a factor as NASA tries to develop a rescue plan.

"These are basically black-and-white patches that computer vision systems can easily identify and use to measure orientation and distance from a target," says Smith, who oversees JWST from NASA headquarters.

Goddard also developed the Hubble Telescope, and studied robotic servicing techniques for it along with planning the instrument repairs and changeouts that were handled by astronauts. Its Satellite Servicing Capabilities Office runs robotic-servicing testbeds on the International Space Station, and it is developing a flight test called Restore-L to demonstrate robotic on-orbit refueling with the Landsat-7 satellite (*AW&ST* May 23-June 5, p. 38).

That free-flying mission will use the launch interface ring on Landsat-7 to

NASA/GSFC

attach itself before the robotic servicing demo, but Smith emphasizes that it would be a major undertaking to take a similar approach on the JWST out at L2.

"If the unthinkable would happen [so] that you have to do something, it would require an entire design effort for such a mission," he says. "At that time we'd have to [decide if] it is worth going up there, investing in this new thing to service something like Webb, because how you would service it would be highly dependent upon what

The complexity of the James Webb Space Telescope makes in-space repairs unlikely, but not impossible.

happened to cause you to need to go there."

The Hubble was designed with a grapple fixture that enabled the shuttle's Canadian-built robotic arm to snare it and place it on a stand in the payload bay for maintenance and upgrades. Smith says it became apparent early in the design process that a similar approach would not be practical on the Webb.

"We did take a quick study of what the deployed, or partially deployed design can handle, and quickly concluded that approaching and touching this very delicate and sensitive observatory presented more risks to the success of the mission than were acceptable," he says. "Rather than spending funds on how to address an unsuccessful deployment or activation, NASA has invested considerable time and money in its build-and-test program to validate, to the highest degree possible, the reliability of those mechanisms and systems that must activate."

If everything goes as planned, it will take about six months for the telescope to cool to its supercold operating temperature and be focused and calibrated, according to John Mather, NASA's senior project scientist on the JWST. Actuators behind them will precisely align each of the primary mirror's segments, which are coated with 3 oz. of gold in total. Gold was selected for maximum sensitivity in the 0.6-28-micron wavelengths that will allow the observatory to peer back into the red-shifted universe to the period post-Big Bang, when the stars and galaxies began lighting up.

Mather says the telescope also will give scientists unprecedented observational capability to study exoplanets, the Solar System and the inevitable surprises. It may be able to detect water vapor and other potential biosignatures in the atmospheres of Earth-like planets orbiting other stars via spectral analysis of light passing through the exoatmospheres.

The Webb also should be able to work in conjunction with the Hubble to study fluctuating phenomena and planets from different angles with different instruments, according to Mather.

"It's good to get them all at the same time with all of the equipment you've got," says Mather, who shared the 2006 Nobel Prize in Physics for his space-based measurements of the cosmic microwave background radiation. "Just [last] week it was pointed out that Hubble and Webb can look at the same planets from different angles. It gives you a stereoscopic viewpoint that I hadn't appreciated. They are a million miles apart. The two eyes are separated by 1 million mi., so you'll be able to see a nice perspective on the planets. I think that's pretty cool."

DISCOVERY AIR DEFENCE/TOP ACES

Discovery Air Defence's Top Aces is answering the Pentagon's call for more contractor-provided aggressor aircraft. Its fleet includes A-4N Skyhawks, Alpha Jets and soon-to-be imported F-16s.

Red Air Rising

Burgeoning adversary industry in the U.S. eyes foreign-owned jets to import as aggressors

James Drew Washington

A new breed of aircraft collector is finding a market at the weapons schools of the U.S. military, where Air Force, Marine Corps and Navy combat aces are trained in the art of air warfare.

SO GOES NELLIS

There is a saying among Air Combat Command's (ACC) fighter groups that as the weapons school and flag exercises at Nellis AFB in Nevada go, so goes the Air Force in terms of training, tactics and doctrine. So when the base turned to contractors such as Draken International to provide much-needed red-air sorties after its F-15 aggressor squadron closed, fighter training locations across the U.S. took note and are now pooling their requirements for training support aircraft.

Nellis says it has an immediate need for more organic and contractor-provided adversary air support for flag exercises, weapons instructor courses, F-22 training and F-35 operational test and evaluation.

The 57th Adversary Tactics Group, which oversees flying operations at Nellis, says the requirements will only increase as more F-35s are introduced. The immediate need cannot be satisfied by more virtual training in simulators or through the use of blended live and virtual assets as an offset—just yet.

The Air Force's aggressor force currently consists of 36 early-model F-16s split between two aggressor squadrons located at Nellis and Eielson AFB in Alaska, plus two groups of Northrop Grumman T-38 Talons supporting F-22 training at Langley AFB, Virginia, and Tyndall AFB, Florida—home to 42 and 49 Raptors, respectively. Draken is also supporting training at Nellis, flying A-4Ks and L-159s.

Through 2025, the Air Force wants to significantly increase its use of fourth-generation-equivalent contractor aircraft support at Nellis and other fighter bases including an undetermined training site on the East Coast. From 2025 onward, it also wants to introduce 70 low-cost "ADAIR-X" platforms, such as T-X derivative or purpose-built aircraft integrated with the next-generation T-X program's live, virtual and constructive (LVC) network. Self-generated aggressors from operational F-16, F-15 and F-35 squadrons will also continue to meet a significant portion of the total sortie requirement, although it is preferable to preserve the service life of these combat-capable fighters by using other aircraft where possible. The service notes in industry day presentations that an expanding portion of its adversary air needs will be met by LVC once the T-X is delivered, but until then it simply needs more aircraft to train against.

Garrick Ngai, a spokesperson for Discovery Air Defence and its Top Aces division, says there is a requirement for contractor-owned, contractor-operated aircraft over the near- and long-term, even as the LVC training network is rolled out under T-X. He says the U.S. market promises to be the largest in the world for ad-

Companies such as Draken International, Tactical Air Support (TacAir), Textron-owned Airborne Tactical Advantage Co. (ATAC), Top Aces and Air USA are searching worldwide for highly capable third- and fourth-generation warplanes, often buying up whole air forces, to support an insatiable appetite for contractor-provided adversary air services.

The reason for this trend toward industry-provided aggressors is threefold. One, the security environment has worsened, with standoffs between U.S. and Chinese and Russian spyplanes, fighters and bombers becoming almost as commonplace as during the Cold War.

Second, after 25 years supporting major military campaigns in the Balkans, Iraq, Afghanistan, Libya and now Syria, U.S. aircraft are wearing out and the slow introduction of replacements means service lives must be preserved and extended. Third, the Lockheed Martin F-22, three F-35 variants and Boeing F/A-18E/F Super Hornets are costly to buy and fly—but also vastly more capable than legacy F-16s, F-15s and F/A-18s—so they must be presented with more adversary aircraft to maximize training value.

Gone are the days of flying one or two "red air" adversarial aircraft against a fourth-generation type. In live training, the F-22 and F-35 need at least four aggressors each to truly make their operators, or "Blue Pilot," sweat.

TacAir CEO and founder Rolland Thompson and James Dormer, senior manager of business development, say the introduction of upgraded "four-plus" and fifth-generation aircraft into the U.S. inventory as well as the "skyrocketing" cost per flight hour of the F-35 and F-22 are driving up demand for adversary air to the point it cannot be provided organically. The U.S. maintains 183 Raptors and declared the F-35B and F-35A operational for the Marine Corps and Air Force in July 2015 and August 2016, respectively. As new squadrons are fielded, more aggressors will be needed for fighter training at weapons schools, flag exercises schoolhouses and operational bases.

"The F-22 and F-35 are so capable that you really need to saturate them with advanced capabilities and higher numbers to challenge the system and stress the pilot," Dormer says. "The Air Force has experienced a budget crunch and decommissioned their F-15 aggressors at Nellis, so they're one squadron down and organically don't have the numbers. The systems they're fielding today are an inordinate amount more complex than they were in the 1960s and '70s, and the cost to use them is orders of magnitude greater, so you need to make every training hour count. We've built a company focused on getting the maximum amount of training from the cost and precious flight hours of those aircraft."

For years, the Navy has employed contractors at its Topgun school such as TacAir and ATAC as advisors and fliers. The latter's supersonic Israel Aerospace Industry (IAI) Kfirs have been flying red air for the weapons school since 2004, operating alongside F-16s, F-15, F/A-18s and the Navy's Northrop F-5 Tiger aggressor groups.

The Air Force has been slower to adopt contracted air support, but when its 65th Aggressor Sqdn. disbanded in September 2014, it reached out to privateers, putting Draken International on contract in late 2015 as a stopgap measure while it explores a longer-term contracting solution.

Air Combat Command says it fell short of its adversary air requirement at Nellis AFB, home of the service's versary air services, just by its sheer number of fighters, and the strategy it puts in place will probably be replicated around the world, particularly by F-35 customers.

"T-X will be the first to introduce a true LVC capability, and we want to be the 'Live' in LVC. That's the domain we want," Ngai says. "The Air Force's inventory is getting very old, and they do not have a lot of cost-effective options left. Simulators cannot do everything for you."

Draken's sole-source contract at Nellis was the first contractual step in a three-phased "AdAir" program for easing ACC into the for-hire aggressor business. ACC is setting up a competition for Phases II and III to meet Nellis's immediate needs for 2018-19 and then out to fiscal 2022. The program has until recently been for Nellis only, but now ACC is taking a servicewide approach by adding other training locations. The program's visibility has been raised to the level of the Office of the Secretary of Defense (OSD).

TACTICAL AIR SUPPORT

Nevada-based Tactical Air Support is expanding its fleet of F-5s to meet Air Force and Navy demand for contractor-provided adversary aircraft.

This could be because the Navy also wants to expand its use of contractor aggressors, seeking aircraft with speed, agility, radar and electronic warfare capabilities similar to the F-16 and F/A-18. There are simply not enough aircraft to go around, and the industry hopes for multiple long-term indefinite-delivery, indefinite-quantities contracts that will allow them to import new fleets and build capacity.

Now we've got the All-Stars running the show, which means this is going to be a very big program," ATAC CEO Jeffrey Parker says of the Air Force AdAir requirement. "They have also highlighted 10 or 12 bases instead of four or five, and the number of flight hours they are planning on funding is truly astonishing. This progression of going from literally nothing to a program plan at the OSD level is really astonishing to watch, and it has surprised all of us who have been beating on their door for 18 years."

premier weapons school, by 3,418 sorties in fiscal 2015 and 3,742 in 2016. It predicts it will need another 30,000-40,000 adversary air sorties per year across the enterprise to meet its training needs. The challenge will only get worse in the early 2020s as the F-35 begins flying from more bases. The Navy is also looking to expand its use of contractor red air, saying it needs more aircraft to present fourth-generation-like combat threats to its carrier-based F-35C and Marine Corps F-35B squadrons as they come online.

There is also a Defense Department-wide requirement for contractor aircraft to support joint terminal attack controller and close-air support courses by dropping bombs during exercises, as well as assets to replicate missile or drone threats and support weapons development and testing.

The demand is not just increasing in the U.S.. Nations with a shrinking, aging fighter force and those looking to induct the F-35 face the same fundamental challenge of generating enough aggressors. Some even want to outsource their red air needs entirely.

TEXTRON/ATAC

An IAI F-21 Kfir belonging to Textron-owned Airborne Tactical Advantage Co. flies alongside a U.S. Navy Lockheed Martin F-35C.

Sean Gustafson, vice president of business development at Draken, says his company launched in November 2011 after sensing strong demand for realistic threat representation. After missing out on a Navy contract that went to ATAC, it shifted its focus to the growing Air Force requirement.

In 2012, the company bought New Zealand's entire combat fleet, a squadron of Kiwi A-4K Skyhawks that were originally operated by Australia and were upgraded with F-16A avionics including APG-66 radar. It also purchased Poland's fleet of 27 supersonic Soviet-era MiG-21s, equipped with "Jay-Bird" radars, and "almost new" Aero Vodochody L-159 advanced light combat aircraft from the Czech manufacturer. The A-4Ks and first three L-159s are now flying at Nellis under the pathfinder contract awarded in 2015, which has been extended through late-2017.

"We bought aircraft before the requirements were needed, and we knew that would shape the future of the industry," Gustafson says. "With the F-35s coming online, you need four adversaries as opposed to two needed for an F-16, F-15 or [Eurofighter] Typhoon. Before it was just the U.S. Navy, and now it's expanded throughout Europe to Germany, and now Canada and Australia are looking at it, too."

Although numbers count, the U.S. government's high-end training requirements demand supersonic aircraft equipped with radars that can detect and track targets beyond 50-100 nm, or that carry government-furnished jammers and electronic threat simulators. These aircraft fetch a premium on the international mar-

Bandits for Hire

Douglas/McDonnell Douglas A-4 Skyhawk

DRAKEN INTERNATIONAL

ROLE: SUBSONIC LIGHT ATTACK
FIRST FLIGHT: JUNE 1954
PRODUCTION: 1954–79, ~2,900 DELIVERED
ENGINE: 1 X PRATT & WHITNEY J52
LENGTH: 40 FT.
WINGSPAN: 28 FT.
CEILING: 42,000 FT.+
OPERATORS: 11+, INCLUDING U.S., ISRAEL, ARGENTINA

Mikoyan-Gurevich MiG-21 'Fishbed'

DRAKEN INTERNATIONAL

ROLE: SUPERSONIC INTERCEPTOR
FIRST FLIGHT: FEBRUARY 1956
PRODUCTION: 1959-85, ~11,400 DELIVERED
ENGINE: 1 X TUMANSKY R-25
SPEED: MACH 1.8
CEILING: 58,000 FT.
LENGTH: 40 FT.
WINGSPAN: 24 FT.
OPERATORS: 60+, INCLUDING SOVIET UNION, POLAND

Israel Aerospace Industries F-21 Kfir

TEXTRON/ATAC

ROLE: SUPERSONIC AIR SUPERIORITY FIGHTER
FIRST FLIGHT: JUNE 1973
PRODUCTION: 1973-86, 210+ DELIVERED
ENGINE: 1 X GENERAL ELECTRIC J79
SPEED: MACH 2
CEILING: 58,000 FT.
LENGTH: 51 FT.
WINGSPAN: 27 FT.
OPERATORS: FIVE, INCLUDING ISRAEL, U.S., COLOMBIA

ket, since they are still considered the "gold standard" of combat aircraft and are typically flown to the end of their useful design life before being sold or junked.

There has also been an acknowledgment that stealthy fifth-generation aggressor support will be needed in the mid-2020s as the Russian Sukhoi T-50 and Chinese Chengdu J-20 are fielded in greater numbers. Industry experts say these capabilities are probably beyond their reach and would likely be too expensive to operate privately anyway.

Top Aces, backed by parent company Discovery Air Defence, says it has secured F-16s sourced from an undisclosed Middle East nation. The Mesa, Arizona-based company is still waiting on State Department approval to import the jets but will move quickly if it captures more adversary-air work with the U.S. military, says company spokesman Garrick Ngai.

"We're going to be the world's first provider of a highly advanced, supersonic-capable, radar-equipped aggressor aircraft. Period," he says without revealing the seller or quantity. "The industry and our customer base know we have access to [those F-16s], and we're working closely with the State Department. Fifth-gen aircraft can chew up red air like there's no tomorrow. To provide meaningful training and a real challenge to the advanced capabilities of these fifth-gen aircraft, you need to at least have a fourth-gen aircraft like the F-16."

Two Draken International A-4K Skyhawks fly alongside a Lockheed Martin F-35 and F-16 at Edwards AFB, California.

U.S. AIR FORCE

Textron Airborne Solutions President and CEO Russ Bartlett and ATAC counterpart Jeffrey Parker say there is strong competition not only for F-16s, but also for Russian and Chinese-origin aircraft if they come with enough spare parts and are backed by the original equipment manufacturer.

"We have our eye on literally every fleet of aircraft around the world that could meet or exceed the requirements coming out of the Navy and the Air Force," Parker says. "We are also looking consistently at countries that fly Russian-made airplanes to make sure we don't miss an opportunity."

TacAir will soon begin importing what's left of the Royal Jordanian Air Force, two squadrons of radar-equipped single- and twin-seat Northrop F-5E/F Tiger IIs. The company already owns what is left of Canada's license-built CF-5Ds, including 65 spare General Electric J85 engines, and now provides maintenance and logistics for the Navy and Marine Corps' F-5 aggressor fleets. Cost, reliability, ease of operation and multi-engine safety steered the company toward the F-5 business, and it has even set up shop alongside Northrop's St. Augustine, Florida, site as an assembly location for future F-5 imports.

"The important thing is logistics; I have seen that destroy squadrons in my career," says Thompson, a former commanding officer at Topgun. "We got all of [Jordan's] spare parts, all of the support infrastructure—we got their entire air force, or what was left of it."

Gallery *See more about the companies that are putting fighter pilots to the test:* **AviationWeek.com/RedAirContractors**

Digital Extra *Will Canada choose Discovery Air Defence or Draken International for airborne training services?* **AviationWeek.com/RedAirCanada**

Northrop F-5 Tiger & Tiger II

ROYAL JORDANIAN AIR FORCE

ROLE: SUPERSONIC LIGHT FIGHTER

FIRST FLIGHT: JULY 1959 (TIGER), AUGUST 1972 (TIGER II)

PRODUCTION: 1959-89, ~2,600 DELIVERED

ENGINE: 2 X GENERAL ELECTRIC J85

SPEED: MACH 1.6

CEILING: 50,000 FT.+

LENGTH: 48 FT.

WINGSPAN: 26 FT.

OPERATORS: 16+, INCLUDING U.S., TAIWAN, SOUTH KOREA, SAUDI ARABIA

General Dynamics/Lockheed Martin F-16 "Viper"

U.S. AIR FORCE

ROLE: SUPERSONIC LIGHTWEIGHT FIGHTER

FIRST FLIGHT: JANUARY 1974 (YF-16), DECEMBER 1976 (F-16A)

PRODUCTION: 1974-2017, 4,500+ DELIVERED

ENGINE: 1 X PRATT & WHITNEY F100

SPEED: MACH 2

CEILING: 55,000 FT.

LENGTH: 49 FT.

WINGSPAN: 33 FT.

OPERATORS: 25+ COUNTRIES, INCLUDING U.S., ISRAEL, PAKISTAN, EGYPT, TURKEY

Aero Vodochody L-159 Advanced Light Combat Aircraft

AERO VODOCHODY

ROLE: SUBSONIC LIGHT COMBAT/TRAINER AIRCRAFT

FIRST FLIGHT: AUGUST 1997

PRODUCTION: 1997-PRESENT, 70+ DELIVERED

ENGINE: HONEYWELL/ITEC F124

SPEED: MACH 0.85

CEILING: 43,000 FT.

LENGTH: 42 FT.

WINGSPAN: 31 FT.

OPERATORS: CZECH REPUBLIC, IRAQ

TONY OSBORNE/AW&ST

Seeing Red

Germany and France lead the way in investing in European adversary air training

Tony Osborne London

While the attention of civilian adversary-air providers may be focused on the future needs of the U.S. Air Force, the concept appears to have been born in Europe.

For 30 years, European air arms and navies have turned to civilian contractors to provide aerial gunnery and electronic-warfare training for ships and aircraft, although only Germany and more recently France have gone the extra mile to invest in commercial adversary-air training.

Much of the need for commercial involvement stems from the high cost of supporting specialist aircraft fleets. Britain's Royal Navy used to fly a fleet of English Electric Canberras to simulate ship attacks, but this capability was replaced on a commercial basis using converted Dassault Falcon 20 business jets that remain in use for the task today.

Discovery Air Defence provides aggressor training and target-towing capabilities to the German air force using seven ex-Israeli McDonnell Douglas A-4N Skyhawks based at Witt-mund AB in northern Germany. Discovery Air Defence snatched away the contract from BAE Systems Flight Systems, which inherited the contract from its takeover of Tracor Flight Systems in 1998. Prior to the Skyhawk, Tracor had been flying F-100 Super Sabres as aggressors and target tugs against Germany's F-4 Phantoms.

The cost per hour of the Skyhawk is as much as one-sixth or one-seventh that of flying the Eurofighter Typhoon, Discovery Air Defence says. Since the beginning of the contract in January 2015, the company has deployed the Skyhawks with the German Eurofighters to Italy and the Canary Islands. The aircraft have also been used to support Germany's Joint Terminal Attack Controller Training.

Germany has long been a user of contractor flying services. GFD-owned Learjets provide electronic-warfare training and EIS GmbH-operated Pilatus PC-9 perform as target tugs.

Key to the commercial provision of an aggressor service is the cheaper rate at which aircraft are offered, much lower than an air force could match, and the alternative aircraft against which they give pilots a chance to fly.

Some German officers say flying against the same type of aircraft can be a negative form of training. Germany should know—it was one of the few Western air arms to operate the Mikoyan MiG-29 Fulcrum, when East and West Germany unified. The MiGs were some of the most sought-after air assets in NATO, flying against many European air arms and participating in the U.S. Air Force's Red Flag exercise. Yet 15-25% of sorties currently flown by front-line aircraft in many European air forces are so-called "red-air" missions to support the training of pilots flying the same type of aircraft.

In France, local training company Secapem in conjunction with Draken International is supporting French naval training, flying A-4 Skyhawks and Aermacchi MB-339s from Nimes.

During the Cold War, European countries enjoyed access to European-based U.S. Air Force aggressor squadrons based in England, and the huge array of different types in the various NATO inventories meant there was a vast range of aircraft against which to train.

Seven Discovery Air Defence A-4 Skyhawks are based at Wittmund in northern Germany to support the German air force's Eurofighter fleet training needs.

Now European air arms have shrunk, budgets have tightened, and the pool of aircraft is decreasing. Several European air forces have their own specialist aggressor squadrons—Britain's 100 Sqdn. flies the BAE Systems Hawk trainer, a French aggressor unit flies the Alpha Jet, and recently Italy deployed its M-346 trainer to Spain to act as an aggressor in the multinational Tactical Leadership Program exercises at Albacete in Spain.

However, the increasing complexity and sophistication of fighters means they need more capable prey against which to train, and two-seat trainers dating back to the 1960s with no radar are simply not enough of a match. It is no wonder then that the big live-flying training companies see market potential in Europe as well.

The UK is considering adding the red-air mission to the Tranche 1 Typhoons that will be part of its fast-jet fleet expansion, scheduled to begin as the Tornado GR4 exits service in 2019. But the UK is also looking to reshape its live air training fleet by including contracted red-air aggressor capability. The Air Support Defense Operational Training (ASDOT) is being studied as a way to deliver red-air and electronic-warfare training under a single umbrella program instead of through several individual contracts.

A competition is due to open in 2017 for a 15-year contract worth up to £1.2 billion ($1.5 billion) if additional phases are added. Several companies have expressed interest in bidding, among them a consortium of Qinetiq and Thales—which selected Textron Airland's Scorpion light attack aircraft—as well as CAE, Draken International and Babcock International.

Studies are also underway within the European Air Group (EAG), an organization set up by seven European air forces to look at "multinational solutions to fulfill a possible common capacity gap for a future Red Air [capability]," EAG's annual report states. "The need for current and future live and synthetic Red Air training was stated as a common requirement which will be further explored," the report says.

Typhoon Win

British pilots name a key factor in mock-combat success

Marhalim Abas Kuala Lumpur

The Royal Air Force (RAF) does not usually claim victory in an exercise—it prefers to stay quiet about such matters. But British Eurofighter Typhoon pilots report that they defeated Malaysian Sukhoi Su-30MKM Flankers in mock battles in October, with a new helmet-mounted sighting system regarded as essential.

Warm-up drills for Exercise Bersama Lima 16, held in Malaysia in October, provided the first opportunity for RAF Typhoons to be pitched against the Su-30MKMs of the Royal Malaysian Air Force (RMAF). The need to attend Bersama Lima has created an opportunity for further exercises in East Asia, so the deployment, Eastern Venture, is also sending Typhoons to Japan and South Korea.

An RAF Typhoon from No. 1 Sqdn. refueling from a Voyager tanker aircraft en route to Malaysia for Exercise Bersama Lima.

CROWN COPYRIGHT

Pilots of the RMAF Su-30s were unavailable for interview, so the RAF claim of victory is unverified. But Wing Cmdr. Mike Sutton, commanding officer of the RAF's 1 (Fighter) Sqdn., which flies the Typhoons, says video recordings of the engagements demonstrate their success.

Sutton points to the importance of the BAE Systems Striker 1 helmet-mounted sighting system (HMSS), which was rolled out to RAF Typhoon squadrons in 2011 and became fully operational in 2015.

"With the Striker 1 HMSS, we just look at the target; we can engage it with a weapon or point our radar on it," he tells Aviation Week at RMAF Butterworth, a base some 350 km (220 mi.) north of Kuala Lumpur. The engagements with the Flankers were within visual range, where the helmet-mounted sight allowed off-boresight missile launches.

"It's amazing the difference it makes" during air combat maneuvering, says Group Capt. Paul Godfrey, the commander of RAF Lossiemouth in Scotland, where the Typhoons are based. Without the HMSS, a pilot in a cloud could "spend all the time looking for the wingman," he notes. "With this, you look and there he is."

The Typhoons did not carry air-combat maneuvering instrumentation pods, Sutton says, so data from the fighters' mission computers was used for debriefing after each sortie.

Targets seen by the pilot on the HMSS can be data linked using Link 16, the NATO standard, to another Typhoon by hitting a switch. Air and ground targets can be designated and fired upon using the same system.

Asked how important the helmet-mounted system is, Sutton says: "It is essential equipment nowadays." Earlier this year, 1 Sqdn. deployed with the HMSS during operations in Iraq and Syria.

Typhoons have not previously appeared with the HMSS at Bersama Lima, an annual exercise of the Five Power Defense Arrangements grouping, which includes Australia, Malaysia, New Zealand, Singapore and the UK. The RAF has deployed eight of the fighters from Lossiemouth to Asia, including six used in the exercise; the other two are in India awaiting orders. The aircraft at Bersama Lima were equipped with the training versions of the AIM-120 Amraam and AIM-132 Asraam air-to-air missiles.

Sutton says the air-to-air duels with the Flankers took place two days ahead of Bersama Lima as a preparation. Also involved in those engagements were Royal Australian Air Force (RAAF) F/A-18 Hornets. The RAAF sent 12 Hornets to Bersama Lima. Later, during the exercise proper, the Typhoons engaged Lockheed Martin F-16s and Boeing F-15SGs of the Republic of Singapore Air Force (RSAF).

It was not revealed how many aircraft took part in the warm-up flights or in the exercise proper. During our interview with Sutton, four Typhoons took off in pairs for afternoon sorties. They departed within 5 min. of engine start. Only six members of the ground crew attended to them.

The engagements with the Malaysian Flankers were the first for RAF Typhoons because the big Russian-built fighters were conspicuously absent during the Bersama Lima deployments of the British aircraft in 2010 and 2012. The RMAF operates 18 Flankers, which were ordered in 2003 and delivered in 2007-09.

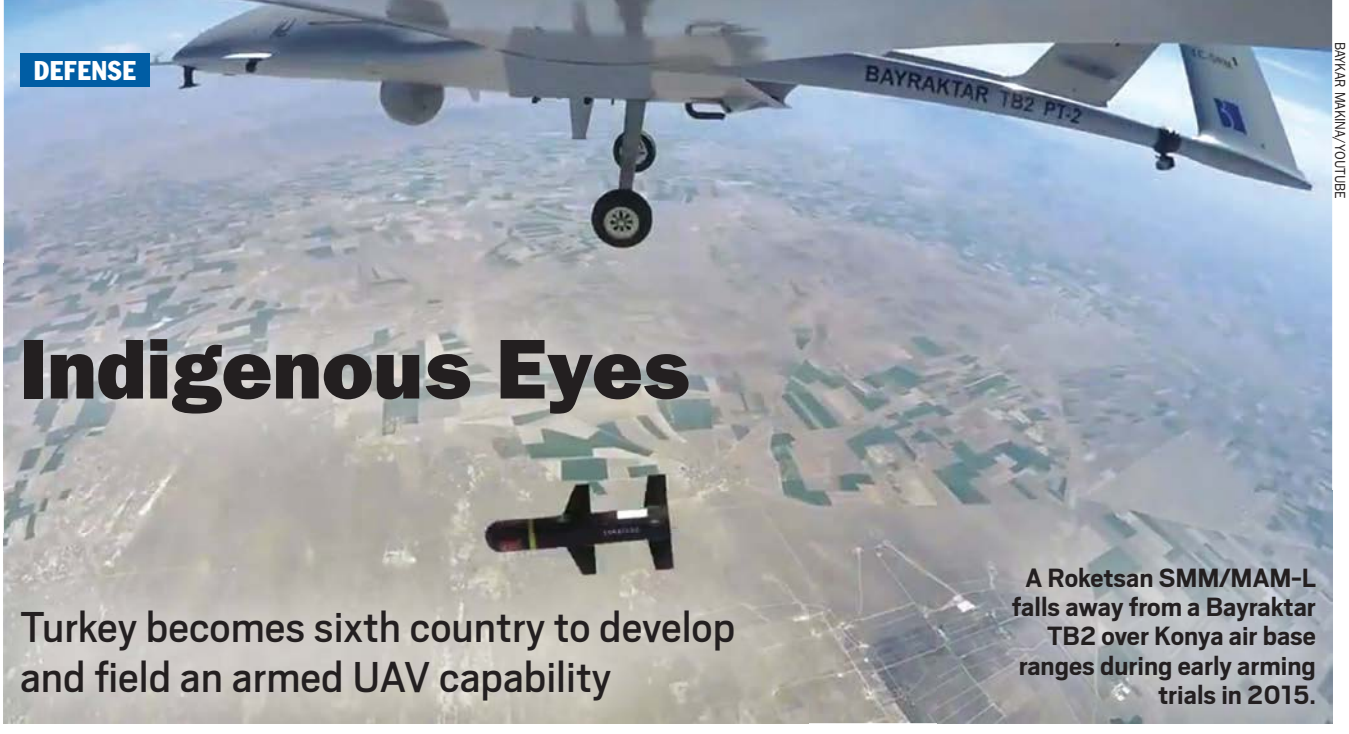
RAF Typhoons exercised in 2015 against four Indian air force Su-30MKIs, similar to the Malaysian fighters. An Indian broadcaster reported that the Indian aircraft won 12-0 but RAF sources said there was no such score and that the Typhoons had performed best. The RAF and Indian government played down the media report.

The Flankers and the RAAF's Hornets also have helmet-mounted sights. The RMAF aircraft used the Ukrainian-designed Sura-M helmet-mounted target designator, while the Hornets are equipped with the Boeing Joint Helmet-Mounted Cueing System.

Sutton says that although the squadron pilots and aircraft were swing-role capable, they were mainly limited to air-to-air in Bersama Lima 16, as that was the capability that the exercise planner asked to have demonstrated.

The Typhoon pilots conducted air-to-air refueling with RSAF KC-135 tankers. Sutton says they were all qualified for refueling with the KC-135s, so they had no issues in doing so. An RAF Voyager tanker accompanied the Typhoons on their long journey from Scotland, but when the group arrived in Malaysia it was sent to the Middle East.

—With Bradley Perrett in Beijing



BAYKAR MAKINA/YOUTUBE

Indigenous Eyes

Turkey becomes sixth country to develop and field an armed UAV capability

A Roketsan SMM/MAM-L falls away from a Bayraktar TB2 over Konya air base ranges during early arming trials in 2015.

Tony Osborne London

The Turkish government has made no secret of its desire to operate armed unmanned air systems, but Ankara's attempts to field foreign-made systems, particularly those from the U.S., have usually not been successful.

But now Ankara has not only fielded indigenous armed UAVs but has sent them into harm's way, targeting the Kurdistan Workers Party (PKK) militants in the southeast of the country. Turkey now becomes the sixth nation to develop and field an indigenous armed UAV system after China, Iran Israel, Pakistan and the U.S.

Details of the first armed UAV missions emerged in late September, when several Turkish newspapers reported that an armed UAV or IHA—air vehicle without human—as they are referred to in Turkey, had killed six PKK militants. The UAVs had also been used to cue Turkish army Cobra helicopter missile strikes.

In October, the country's defense minister, Fikri Isik, confirmed that the armed systems had killed 72 PKK fighters in the Hakkari region over a two-month period. Isik's statement—communicated via Twitter—was the first official government confirmation that the armed UAVs were being used.

It has since emerged that the first strikes took place in early September using privately owned UAV company Baykar Makina's Bayraktar TB2, the first of two locally developed platforms that have been pressed into the armed surveillance mission.

Several Turkish newspapers have published transcripts of communications among PKK fighters describing the apparent impact that the systems have been having on their operations. "Wings without men are killing us," one PKK fighter reportedly said. "When they see our heads, they just bomb us." This suggests that the UAVs had inflicted heavy casualties and were sapping morale.

"Turkey views the UAVs as a force multiplier for its current military operations against the PKK," says Aaron Stein, senior fellow at the Atlantic Council and an expert on Turkish defense. "There is also considerable government support to develop an indigenous defense sector, including UAVs," he says.

Work to begin outfitting the locally built platforms began in earnest in 2015 with Baykar Makina developing a weapon capability for the Bayraktar TB2, pairing it with Roketsan's Small Micro Munition (SMM) also known as MAM-L, a 50-lb. (22-kg) laser-guided munition. The capability was proved to senior Turkish military officials in December 2015 during drop trials at a test range in Konya. Later, Vestel Savunma added an armed capability to its Karayel UAVs in service with the Turkish land forces—the main branch of the army—allowing them to drop up to two SMMs. Reports in Turkey say this work was carried out in just three months. Both platforms are entirely indigenous, which frees them from U.S. International Traffic in Arms Regulations, and so theoretically will be easier to export.

Turkey has tried several times to procure armed UAVs. In the early 2000s, the country purchased IAI Herons from Israel, but Ankara was reportedly unhappy both with the drone's performance and lengthy delivery delays. In 2010, an Israeli commando raid on a Turkish ship headed for Gaza resulted in a dramatic deterioration in Israeli-Turkish relations that are only now being repaired. Ankara's requests for the General Atomics MQ-9 Reaper failed to meet U.S. State Department approvals.

An amalgam of these frustrations has pushed Turkey down the indigenous path. In May, Ismail Demir, undersecretary of Turkish Defense Industries, told a think tank in Washington: "I don't mean to be sarcastic, but I would like to thank [the U.S. government] for the projects that were not approved because it forced us to develop our own systems."

Ankara now has ambitions for an even larger armed UAV platform. In early September, the minister of science, industry and technology, Faruk Ozlu, announced a goal to create 3.5-4-metric-ton platforms with more advanced sensors and weapons.

The basis of such a platform could be Turkish Aerospace Industries' new model Anka-S medium-altitude, long-endurance air vehicle, the first fully equipped prototype of which flew on Sept. 25. Unlike previous versions of the Anka, the Anka-S is fitted with a beyond-line-of-sight communications system for over-the-horizon use. Ten Anka-S have been ordered by the Turkish air force; deliveries of the first two systems, set to take place in the first quarter of 2017, are to be used for acceptance trials. Two batches of four aircraft will follow later.

Course Correct

Brazil's Helibras hopes to widen scope of work with parent Airbus

Tony Osborne **Itajuba, Brazil**

When Eurocopter opened a new assembly line for the EC725 Caracal helicopter here in October 2012, the company had ambitions that its Brazilian affiliate Helibras could hone the skills to develop an indigenous helicopter in the 2020s.

But four years on, the company, now Airbus Helicopters, has tempered those ambitions.

In the midst of one of the worst economic and political crises in Brazil's history, the Brazilian commercial helicopter market has slumped and military programs have been pushed to the right.

Aspirations to build the commercial H225 helicopter for the Brazilian oil and gas market have also been dashed because of the fall in energy prices.

But this has not stopped Helibras from developing talents that could eventually be used to build an indigenous platform.

Thanks to technology transfers that were part of the H-XBR program to deliver the Caracals, the company has been able to embark on a number of significant retrofits and upgrades to military platforms that have provided valuable experience.

The Brazilian navy plans to purchase five H225Ms that can fire the Exocet antiship missile, a capability developed by Helibras.

Emboldened, Helibras now wants to play a greater role and work more closely with colleagues in Europe on projects beyond Brazil's borders.

"I want to be able to support the mother company with projects for niche markets," says Helibras President Richard Marelli. "My design office is qualified in the same way as the design office in Marignane [Airbus's main site near Marseille]. My flight-test engineers and pilots are at the same level, so if I develop one installation here, Marignane can use it." Marelli adds that he wants "to develop activity in Brazil, even if it is not for Brazil."

But times are tough. Helibras sold just two commercial light helicopters last year, and it is targeting sales of seven aircraft this year but has yet to receive down payments on five of them.

By comparison, in an average year, the manufacturer would deliver 25 aircraft annually.

Despite the economic challenges, few of Brazil's military programs have actually been canceled or postponed. Instead, they are being renegotiated in the hope that the fiscal situation will improve in the near future.

The H-XBR program, under which 50 EC725 (now H225M) helicopters are being assembled locally for the Brazilian armed forces, has helped to grow Helibras's capabilities, but the production rate is being slashed and deliveries, originally due to be completed by the end of 2017, have been pushed back to 2022. However, the program will still meet its aims of featuring 50% Brazilian content, and 37 local companies are involved as suppliers. Meanwhile, upgrades for the Brazilian army's AS550/H125M Esquilo/Fennec and AS565 Super Pantera K2 have also been delayed. The Pantera program had been due to conclude in 2021 but will now be completed in 2024, while the Esquilo upgrade will run for another three years, until 2022.

The development of the Super Pantera is one of the most complex programs undertaken by Helibras, building on what the U.S. Coast Guard has done with its HH-65 Dolphin search-and-rescue helicopters, adding the Arriel 2C2 engine, a new main gearbox, an improved fenestron antitorque system and a new avionics suite, including a four-axis autopilot.

Helibras's integration capabilities have also been tested with development of an H225M version for the Brazilian navy armed with an antiship missile. Five of these 16 H225Ms will be delivered in the new configuration, which will allow the helicopters to guide and launch two 655-kg (1,500-lb.) MBDA Exocet Block 2 missiles. Airbus last integrated such a weapon onto a helicopter more than 20 years ago on rotorcraft destined for Saudi Arabia and Chile.

The helicopters have been equipped with a Star Safire 3 electro-optical camera in the nose and a Telephonics APS-143 OceanEye radar as well as the Saab IDAS3 defensive aids suite, which provides self-defense capability and doubles the aircraft's electronic support measures systems. The Brazilian navy wants the H225M to be able to operate from ships and land bases with an over-the-horizon capability to target ships. The helicopter's range could also be extended with aerial refueling, although adding a refueling probe would cost the carriage of one weapon.

TONY OSBORNE/AW&ST

Qualification testing of the Exocet-armed H225M is underway, and the helicopter is due to enter service in 2018, with deliveries following at the rate of one per year until 2022.

Helibras has identified a number of other opportunities for potential upgrades for Latin American fleets of Cougar utility helicopters as well as Panthers operating in Chile and Argentina, and it sees potential in Airbus's development of the Hforce generic weapon system to arm dual-use helicopters. Marelli is working with the Brazilian army to retrofit Hforce onto the service's Fennecs and wants to modify one as a demonstrator.

Meanwhile, he is optimistic that Brazil is heading for recovery and interest in helicopters will increase. "The economic situation in Brazil is not so good, but since the impeachment [of Brazilian President Dilma Rousseff], we have a stabilization," Marelli says.

Copa America

Copa Holdings is setting up a ULCC as part of its Copa Airlines Colombia subsidiary

Madhu Unnikrishnan San Francisco

Copa Airlines is seeking to diversify its business model by soon launching an ultra-low-cost-carrier (ULCC), Wingo, in Colombia. It will operate as a subfleet of its existing subsidiary, Copa Airlines Colombia.

If the concept works, the Panama-based company could export the model to other countries in which it operates. But will it succeed in creating an airline-within-an-airline? The strategy has produced notoriously mixed results. And even if it proves to be successful in Colombia, could it be replicated elsewhere in Latin America?

Copa says its rationale for launching a new Colombian airline is to better match product with demand. "There was a mismatch in Colombia," CEO Pedro Heilbron tells Aviation Week. "We were offering a full-service and expensive product in a low-yield market where we couldn't compete."

Wingo will be a ULCC with an unbundled service offering, compared with Copa, which offers two classes of service, complimentary food and checked bags. Wingo will launch with four Boeing 737-700s configured in a single class of service with 142 seats, compared with mainline Copa aircraft of the type that have 12 business- and 112 economy-class seats.

The new airline will function as a subfleet within Copa Airlines Colombia under that company's Colombian air operator's certificate, Heilbron says. The four aircraft are being reconfigured and painted, and are expected to go into service as Wingo aircraft on Dec. 1. Copa's Colombian subsidiary is expected to have 17 aircraft in total.

Heilbron acknowledges that a subfleet could be a risky move. "In the past, legacy carriers have tried to establish LCCs or ULCCs with mixed results," he says. "We are confident [of success], because Copa has always been a very cost-efficient airline."

In the early 2000s, both United Airlines and Delta Air Lines tried launching separate carriers as a subfleet of their existing operations—United with Ted and Delta with Song. The experiments failed; both sub-entities folded within a few years. However, Air Canada has been highly successful with its Rouge subsidiary, proving the model can work if executed well and in an environment, such as Colombia, where pilots unions are not as strong as they are in the U.S., analysts say.

Heilbron's disciplined management team should be able to pull it off. "Normally, I'm not a big fan of an airline-within-an-airline," says Cowen & Co. analyst Helane Becker. "[Management must] show employees the reason for the separate model, but this is a particularly high-quality management team and they should be able to do it."

Despite the "product mismatch" Heilbron described, Copa's Colombian subsidiary, Copa Airlines Colombia, currently serves three distinct missions and has not been as profitable as Copa's main Panama-based airline, he adds. First, it operates flights between nine Colombian cities and Copa's main hub at Tocumen International Airport in Panama City. These flights will continue to operate with two-class aircraft.

Second, Copa Airlines Colombia operates domestic routes in that country. And third, it operates leisure routes from the capital, Bogota, to the Caribbean. These last two missions will be assigned to Wingo, Heilbron says.

Embraer E190s currently operating in Colombia will transfer back to Copa's Panama-based airline, he says.

One thing that differentiates Wingo from Rouge, Song and Ted is that it will have a separate distribution model from Copa's. To keep costs low, tickets will be available only through Wingo's website. In an effort to reach "unbanked" customers—those without access to credit cards or bank accounts—Wingo tickets also will be sold for cash at certain supermarkets and the airport in Bogota.

"Having a separate reservations system is really radical," says Craig Jenks, founder of New York-based consultancy Airline/Aircraft Projects Inc. "It sug-

COPA AIRLINES CONCEPT

Copa Holding is diversifying its Colombian operations with Wingo, a new ultra-low-cost carrier, set to launch in that country on Dec. 1.

The Wingo Way

- Its four-aircraft subfleet will operate on Copa Airlines Colombia's air operator certificate—Copa Colombia will have 17 Boeing 737s, including Wingo's. The carrier's Embraer E190s will transfer back to Copa's mainline carrier in Panama.
- Its aircraft will have their own livery and be configured with 142 seats in a single class, compared with 124 seats in a dual-class configuration for Copa mainline.
- It will fulfill two of Copa Colombia's missions: intra-Colombia flying and flights from Bogota to leisure destinations in the Caribbean. The mainline carrier will fly between nine Colombian cities and Panama.
- Its reservations system will be separate from Copa Airlines and Copa Colombia. Wingo tickets will be sold directly from Wingo's website and at the Bogota airport as well as at supermarkets and cash payment centers. They will not be sold on global distribution systems or via call centers.

gests that this new one will have zero interlining with Copa mainline, and that Wingo will operate as a pure ULCC. This is not a half-hearted segmentation," Jenks continues. "This is bold."

Another bold idea could be exporting the Wingo model to other countries, although risks mount. On the one hand, Copa needs to grow beyond its successful business connecting North, South and Central America through its hub at Tocumen, and the Panama domestic market is minuscule. Arguably, the airline began to diversify when it finalized the deal to buy Aero Republica in 2010 and converted that airline into Copa Airlines Colombia.

Copa's competitors are expanding in the region. Mexican ULCC Volaris last month detailed plans for its own Costa Rica subsidiary. VivaLatinamerica—the ULCC holding company that operates Mexico's VivaAerobus and Colombia's VivaColombia—is backed by Ryanair's founding family and has had ambitious plans to launch a new airline every year but has since scaled back its vision.

So could Copa join the fray? Heilbron notes that Wingo is a test run. "With Wingo we will gain ULCC expertise," Heilbron says. "We will have a unit where we can learn how to be a ULCC that we can export to other countries."

But which countries might be viable is far from clear, says Jenks. "It's not like people aren't trying in any significant market in Latin America." Jenks believes another possibility for Copa is to establish elsewhere the type of hub-and-spoke model it uses in Tocumen—becoming what he calls a "multihub Latin American airline"—rather than setting up discrete ULCCs. "Copa really does face a choice," he says.

Cowen's Becker also sees difficulty in expanding the Wingo model. Although much of the physical geography of Central and South America makes flying—rather than surface transportation—an attractive proposition, "Are there that many countries with a population wealthy enough to afford flying?" she asks. And second, ULCCs work best when stage lengths are short; but in much of South America, population centers are far-flung. In many South American countries you might be able to do only one flight a day, and that is problematic for a ULCC, she notes.

But Heilbron is optimistic. "In Colombia, we are converting a network that we are already operating—one we know and operate very well," he says.

Mexico Rising

There will be more competition in Mexico's airspace, but nothing is set in stone yet

Kristin Majcher Boston

Airlines overwhelmingly applauded the recent updated bilateral aviation agreement between the U.S. and Mexico, which allows more carriers to compete on routes between the two countries. And pending developments could have even more far-reaching effects on Mexico's air transport market.

The long-awaited new bilateral pact, which rescinds limits on the carriers in each country that can serve transborder routes, finally entered force on Aug. 21. It had been slated to take effect in January, but Mexican senate ratification and the integral step of exchanging diplomatic notes held up the process.

Now airlines can apply for routes that had been denied them due to a maximum-airlines cap under the previous bilateral's terms. So far, this appears to have the most impact on flights to leisure and beach destinations, and competition on these new routes is expected to ramp up soon as colder weather and multiple winter holidays approach.

Delta Air Lines and Southwest Airlines both announced new services between Los Angeles and Los Cabos, Mexico, which American Airlines, United Airlines and Alaska Airlines already serve. Delta plans to start daily service between the airports on Dec. 17, and Southwest plans to start twice-daily service Dec. 4. Also in December, Delta will introduce service between New York's John F. Kennedy International (JFK) and Cancun International, a route that its partner, AeroMexico, currently offers along with JetBlue Airways, American Airlines and Mexico's Interjet.

Southwest also plans to start two other routes on Dec. 4, in addition to Los Cabos. The airline is planning service between Los Angeles International Airport (LAX) and Cancun twice daily. Delta, United and Virgin America operate that route with vary-

A recent bilateral agreement to strengthen Delta Air Lines' and AeroMexico's eligibility to serve transborder routes means each airline must relinquish some slots at JFK and Mexico City International.

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ing frequency, and Interjet added the route on May 19. Southwest will also begin daily service between LAX and Puerto Vallarta, a route that Delta, United and Alaska already fly.

In addition to enabling these new routes, the new bilateral is significant for another reason: It was a prerequisite for SkyTeam partners Delta and AeroMexico to solidify a joint venture agreement. This was to allow the airlines to work more closely on scheduling, route planning, sales and pricing, and to increase their network and frequencies within Mexico.

On Nov. 4, the U.S. Transportation Department proposed approving antitrust immunity for Delta and AeroMexico's joint venture, but with conditions including divestiture of slots in Mexico City and JFK. The airlines first applied for antitrust immunity in late March 2015.

The Transportation Department said the airlines would have to divest enough roundtrip slot pairs to facilitate 24 daily services between the U.S. (JFK) and Mexico at Mexico City International (MEX), and to open six daily transborder flights in New York. In addition, it proposed limiting the antitrust immunity for the partnership to five years.

"The department tentatively finds these conditions are necessary to prevent harm to consumers resulting from the carriers' dominant positions at MEX and JFK, and the inability of new entrant carriers to access slots at the airports," according to a Nov. 4 statement.

The Transportation Department also proposed that the slots be made available only to low-cost carriers (LCC). Several airlines, including JetBlue and Southwest, have raised concerns about how the proposed deal would affect competition in Mexico City, citing problems with gaining commercially viable slots there.

"While we recognize that other large airline network competitors will also exert some degree of competition in the market, the department has previously found that LCCs have the greatest competitive impact when entering constrained markets," the Transportation Department filing said. "We tentatively believe that the same market dynamics will apply here and . . . to keep the number of divested slots to a minimum while achieving the neces-

Havana and Beyond

Some U.S. airlines are cleared to offer flights to Cuba, but want later start dates

JETBLUE

Kristin Majcher Boston

JetBlue became the first U.S. carrier in more than 50 years to offer scheduled service to Cuba. Its inaugural flight to the island nation's Santa Clara took place on Aug. 31.

For the first time in more than 50 years, U.S. carriers are offering scheduled flights to Cuba. However, many airlines have asked for a bit more time to start Havana flights past the imposed deadline in late November, which falls right after the Thanksgiving holiday period.

Many services to Cuba have not yet started, and those that have are relatively new. The U.S. Transportation Department granted airlines increased access to Cuba's non-Havana frequencies in June, followed by 20 coveted slots to the capital city through a final order released on Aug. 31.

The Transportation Department elected to award services to Havana to the following: Alaska Airlines, American Airlines, Delta Air Lines, Frontier Airlines, JetBlue Airways, Southwest Airlines, Spirit Airlines and United Airlines. Two other carriers, Eastern Air Lines and Silver Airways, were not selected despite filing objections to the Transportation Department's tentative decision.

For the non-Havana frequencies, American, JetBlue, Silver, Frontier, Southwest and Sun Country Airlines received awards. Those airlines will fly to Cuba's nine secondary cities from five U.S. cities: Miami, Chicago, Philadelphia, Fort Lauderdale, Florida, and Minneapolis.

JetBlue was the first airline to launch the renewed scheduled flights with its service between Fort Lauderdale and Santa Clara, Cuba, on Aug. 31. The airline subsequently launched service to Camaguey, Cuba, on Nov. 3.

Under the Transportation Department's final order, airlines were required to start flights by Nov. 29. However, many carriers have requested more time to start the flights for various reasons. In many cases the extensions are only for a few days, but a few seek a longer period to prepare for Havana flights.

For example, Southwest Airlines requested an extension to Dec. 12. The airline had cited that date when it announced that tickets were on sale in mid-October. The Transportation Department approved the request in an Oct. 21 filing.

"Due to airport facility constraints, time required to train local support personnel and the complexities associated with positioning equipment in Cuba, Southwest has determined

sary competitive discipline, we are tentatively proposing to limit eligibility to acquire the divested slots to U.S. and Mexican LCCs and low-fare carriers."

The airlines already accepted the terms of Mexico's competition authority Cofece earlier this year, which included a condition to yield eight slot pairs in Mexico City to other carriers.

In a separate proceeding from the one pertaining to the proposed Delta-AeroMexico deal, Cofece issued a preliminary report in February stating that the airport's slot-allocation procedures had anti-competitive effects, and proposed ways to amend those procedures. The U.S. Transportation Department said it considered the report when it drew up its tentative proposal.

In addition, antitrust immunity would pave the way for Delta to increase its stake in AeroMexico, the latter airline's CEO, Andres Conesa, mentioned on the latest analyst call. Delta announced in November 2015 that it intended to acquire up to 49% of the carrier; at the time it owned about a 4.1% stake in the carrier's outstanding shares with an option to add a further 8.1%.

Now that the Transportation Department has issued a tentative decision, airlines will be able to submit public comments about its specific proposal. Interested parties have until Nov. 18 to submit comments, and until Nov. 30 to reply to them. After that, the Transportation Department will make its final decision about whether to officially grant the carriers antitrust immunity.

Mexico City is poised to add significantly more capacity in the long term, thanks to a new airport under construction there. According to a recent presentation by airport planning officials, the facility will be designed to handle up to 68 million passengers per year during its first phase of operation slated to run from 2020-30. By comparison, Mexico City's current airport traffic was about 38.4 million passengers in 2015, airport statistics show. In those 10 years, the airport will have three parallel runways with simultaneous operations, and one terminal building.

Plans exist to further expand the airport's footprint. At its maturity by 2065, it is anticipated the airport will grow to 125 million passengers per year and have six parallel runways, with three able to operate simultaneously.

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that a modest extension is in the best interest of Southwest and our valued customers, as well as the entities and personnel that will be supporting our operation at [Havana]," the carrier wrote in its Transportation Department filing. "Indeed, Cuban officials recently suggested that Southwest consider initiating service in December to allow all parties time to make final preparations."

JetBlue also cited airport issues in an Oct. 31 filing, in which it asked the Transportation Department to grant it more time to start up daily frequencies between Fort Lauderdale and Holguin, Cuba, which are set to start on Nov. 10.

"Due to a delay in obtaining slots at Frank Pais Airport in Holguin, JetBlue was unable to commit to daily service beginning on Nov. 10, 2016, without risking customer and crewmember disruption related to its existing schedules for November and December, including aircraft allocation schedules," the airline wrote in the filing.

The airline said it will still launch service on that day, but will run the service four times per week until Jan. 4 "when daily service will begin at operationally feasible times."

The Transportation Department has also awarded several airlines short extensions to initiate flights to Cuba, with many opting to start the Havana services on Dec. 1. JetBlue was awarded a two-day extension to begin Fort Lauderdale-Havana service on this day, as well as Frontier Airlines for its Miami-Havana flights and Spirit Airlines for its Fort Lauderdale-Havana route.

Delta Air Lines, which gained approval to start Havana flights from New York's John F. Kennedy International Airport, Atlanta and Miami, requested a two-day extension to start Havana flights on Dec. 1. It said the extension would allow it to better serve customers over the busy travel season around the Thanksgiving holiday on Nov. 25. American Airlines also has a pending request for a one-day extension to three of its four Miami-Havana frequencies, as well as a one-day extension for its Charlotte, North Carolina-Havana service.

Most petitions for date adjustments went unchallenged by carriers, with the exception of Alaska Airlines' request to push back its Havana-Los Angeles service more than a month, to Jan. 5. The carrier said the original late-November start date was problematic because of the tourism restrictions on U.S. travelers to Cuba, which still remain in effect. Although scheduled flights between the U.S. and Cuba have begun, U.S. citizens are not allowed to visit Cuba solely for tourism purposes. Alaska said most U.S. travelers are visiting the Caribbean for leisure during this period, and the restrictions would limit their vacation plans.

JetBlue, however, promptly objected, and urged the Transportation Department to deny Alaska Airlines' request. It asked that it be granted the frequency so that it could start nonstop daily flights between Boston and Havana, or at least "backup authority" on the route in the event that Alaska did not use it in the future.

"While it is possible that a U.S. carrier might have legitimate reasons to postpone the launch of Havana service for a few days past the 90-day deadline, particularly as the Nov. 29 deadline follows immediately after the peak Thanksgiving travel weekend, a 37-day delay is clearly a commercial decision to not serve a new market over the December holiday season and evidences a lack of preparation and readiness to accept the department award of this scarce resource," JetBlue said of Alaska's proposal.

In the end, the Transportation Department decided to grant Alaska the start-up extension for the route, and denied JetBlue the backup authority.

"The department does not find JetBlue's objection sufficiently compelling to forgo the anticipated benefits of Alaska's proposed Los Angeles-Havana service," the Transportation Department said in the filing. "The department recognizes that, in granting an extension of the start-up deadline, the anticipated benefits of Alaska's service might be somewhat delayed. On balance, however, and in the circumstances presented, the department has determined that a relatively short delay does not warrant the carrier's loss of authority and the reallocation of the frequency to an alternative carrier and gateway," it said.

As Difficult as it is to Achieve, 2016 Program Excellence Award Winners Hit the Mark

In today's aerospace and defense environment, achieving excellence is no easy task. Programs are more complex, their technologies more advanced, their customers ever-more demanding.

Whether it's guarding the borders, managing air traffic, designing an all-new system or sustaining an aircraft that has flown for decades, program managers continue to push to higher levels of employee engagement, to learn from the experience of others, and to carefully look at data and trends to determine what ***might happen***.

And it is in this cloudy area of what might happen that true program leaders identify unknown risks. Or they see a gap, a glimmer of opportunity to make a system work better, boost a team to improved efficiency, or innovate a process or technology that will keep the program relevant.

This year's Program Excellance nominated programs were judged on the basis of creating value—for customers but also for the companies and entire value chain involved in the program; managing market and technological complexity; organizational excellence; and metrics that exceed basic requirements to indicate ongoing ability to execute.

Each program team submitted data for the period January 2013 to January 2016. Evaluators included program leadership experts from industry, academia and government agencies.

The Aviation Week's Program Excellence Awards were established in 2004 as a joint effort by leaders from government agencies, academia and industry to identify best practices and develop the next generation of program leaders.

2016 PROGRAM EXCELLENCE WINNERS

SPECIAL PROJECTS

National Cyber Range

Program Leader: Patrick Lardieri, Chief Engineer/ Lockheed Martin Fellow

The National Cyber Range helps Defense Department development programs understand and mitigate their system's cyber-attack surface in a broad system-of-systems operational environment, and helps cyber warriors train to defend US systems against adversaries with constantly changing tactics and technology. Among the unique aspects of this Special Project was a unique measure—"willingness"—which was the gauge as to acceptance of help on a topic that affects every program but that isn't usually fully understood as a program necessity.

Lockheed Martin's National Cyber Range program claimed the Special Projects category award. Patrick Lardieri, right, is the program's chief engineer. Joining him are, from left, Peter Christensen, director of the NCR for the Defense Departmebnt's Test Resource Management Center, and Carole Rickard Hedden, Aviation Week's Program Excellence project leader. (Photo Credit: Guy Mancuso Photography)

SUB-SYSTEM R&D/SYSTEM DESIGN DEVELOPMENT

James Webb Observatory Telescope Program

Program Leader: Scott C. Texter, Telescope Program Manager, Northrop Grumman

The Webb Telescope is intended to observe the birth and evolution of the first stars and galaxies, which came into existence after the Big Bang. In addition to developing this one-of-a-kind telescope, the team broke the cost/learning curve—the holy grail of program leadership. The Telescope has, in effect, experienced an equivalent doubling of capability per

unit cost, about every four years.

Along the way to delivering to more than 13,000 requirements, the team refined best practices in supply chain teaming, handling and dispensing of risk, and putting into place predictive indicators to cover more than 50,000 logic-linked tasks.

SUB-SYSTEM LEVEL PRODUCTION

Mars Atmosphere and Volatile Evolution Mission (MAVEN)

Program Leader: Guy Beutelschies, MAVEN Program Manager, Lockheed Martin

Long ago, Mars had rivers, lakes, and oceans; today it is a barren desert, indicating the atmosphere was once much thicker than it is today. The Mars Atmosphere and Volatile Evolution (MAVEN) mission is designed to figure out what happened to the Martian atmosphere. MAVEN represented an opportunity demonstrate innovative management techniques for controlling costs. Planetary spacecraft are expected to meet all of its mission requirements including the hard launch deadlines dictated by orbital mechanics, but to do so while under running budget by 8% is unprecedented. The team also worked to reduce complexity, while increasing the spacecraft's flexibility in use.

SUB-SYSTEM LEVEL SUSTAINMENT

Javelin Joint Venture Life Cycle Contract Support Program

Program Leaders: John Halvey, JJV President, Raytheon; and Richard Benton, JJV Vice President, Lockheed Martin

The program enabled successful missions in Southwest Asia, better than 99% mission reliability, and less than 2-day material availability while providing $45M savings over the past 2 years. The effort has a mix of both Firm-Fixed Price and Cost Plus Fixed Fee agreements. Modeling using real data from the previous contract versus directed OPTEMPO and reliability failure projections allowed for extremely accurate supportability predictions—and improved over all performance.

SYSTEM LEVEL R&D/ SYSTEM DESIGN AND DEVELOPMENT

Boeing's MH-47G New Build

Chuck Dabundo, Vice President of Cargo Helicopter Programs/H-47 Program Manager, Boeing Defense Space & Security

This team developed and delivered its first aircraft in less than 24 months—to the delight of the team's Special Operations Command customer. The team transformed older CH-47 aircraft into new, long range, assault aircraft. Using a new airframe baseline developed for Canada, the program team designed a monolithic frame, reducing manufacturing time but also increasing the airframe's strength and "tuning" that frame to reduce vibration. The close work between SOCOM, Boeing and suppliers allowed sup-

Sub-System Research and Development/System Design Development winning award went to the James Webb Space Telescope program. Aviation Week's Carole Rickard Hedden congratulates Lee Feinberg (center), telescope manager for NASA Goddard Space Flight Center, and Scott C. Texter, telescope manager for the James Webb Space System, Northrop Grumman Aerospace. (Photo Credit: Guy Mancuso Photography)

The space sector of the aerospace and defense industry also claimed the sub-system production category award. Guy Beutelschies, director of the Mars Atmosphere & Volatile Evolution Mission for Lockheed Martin, receives the award at the annual Program Excellence Awards banquet. With him is Aviation Week's Carole Rickard Hedden. (Photo Credit: Guy Mancuso Photography)

The Javelin missile remains one of the U.S. Army's most dependable – and affordable – missile systems, thanks to the work of the Javelin Joint Venture, a partnership between Raytheon and Lockheed Martin. The JV's leaders are John Halvey (left), president of JJV from Raytheon, and Richard Benton, JJV vice president from Lockheed Martin. Congratulating the duo is Jen DiMascio, Aviation Week's managing editor-defense and space. (Photo Credit: Guy Mancuso Photography)

Sometimes making what is old all-new again makes a critical difference for the end-user, the warfighter. Such is the case for this year's System R&D/SDD winning program, the MH-47 New BuildMH-47. The refresh of the Chinook, from airframe to sub-systems, was completed in 24 months using a digital design-to-production approach. Celebrating the win for the Boeing team are (from left to right) Charles Lee, David Koopersmith, Scott Merrell, Chuck Dabundo, Kevin Cohen, Rob Boyton, Jeff Harling and Aviation Week's Jen DiMascio, managing editor-defense and space. (Photo Credit: Guy Mancuso Photography)

Aviation Week's Program Excellence awards recognize more than that which flies – the infrastructure required is just as important. This year's System Sustainment program winner is Project Marshall, a UK Ministry of Defense program to transform and maintain air traffic management for MoD sites around the world, for both civil and military aircraft. Aquila Air Traffic Management Services — a venture between Thales and the UK's NATS — took the award home. Accepting the award from Jen DiMascio, Aviation Week's managing editor-space and defense, are (left) Tedd Davies, deputy for the UK MoD Prject Marshall Office, and (center) Justin Barratt, managing director, Aquila Air Traffic Management Services/Thales. (Photo Credit: Guy Mancuso Photography)

pliers to plan more realistically, reducing time and cost. The engineering team used a new digital design approach to reduce errors and interference while improving first-time quality. This digital approach became part of the team's DNA—modeling provided visual context, and enabled virtual reviews as the team moved forward.

SYSTEM LEVEL PRODUCTION

Mobile User Objective System Program

Program Leader: Iris Bombelyn, former MUOS program manager and current VP of Protected Communications and Advanced EHF Programs, Lockheed Martin

This is the story of how a military space systems team dug deep into its commercial satellite roots, crafting a balanced approach to deliver on a fixed price commitment, achieving production efficiencies and extraordinary mission success. Lockheed Martin proceeded in advance of the contract options closure to acquire long-lead items at risk. This resulted in cost-per-hour savings , build over build, of 20% to 40% depending on the maturity/complexity of the part. Parts defects dropped 80% from first build to last. In addition, the satellite carries two payloads—one that is new generation and a second that deals with legacy systems, providing an easy mode of transition. The team designed next-generation systems that took advantage of components, subsystems and spacecraft that were previously proven. Another philosophy was to provide opportunities for people to rotate within the program. Thus an engineer who started on the production floor could rotate into a systems engineering position on the program, and then support on-orbit mission test operations—creating a learning environment, but also keeping employees engaged with the mission.

SYSTEM LEVEL SUSTAINMENT

Aquila Air Traffic Management Services' Project Marshall/UK Ministry of Defense

Program Leader: Justin Barrett, managing director for Aquila Air Traffic Management Services

This program transformed terminal air traffic management for all MoD sites around the world to enable civil and military aircraft to operate safely in military terminal airspace with no loss of tactical freedom. Project Marshall combined 70 different projects into a single effort. The only requirement was output of flights handled, with no definition of the technology required included. With a combined effort from the Aquila program office, Thales and the UK's National Air Traffic Systems, the team dramatically increased system availability and flight throughput, achieved required certification and has built in a process to continuously upgrade the operations. In all, Project Marshall has saved the British government 1 billion pounds.

2016 PROGRAM EXCELLENCE FINALISTS

SPECIAL PROJECTS

C-17 Program Transition

Troy Dawson, VP/Program Manager, The Boeing Co.

Hunter Unmanned Aircraft System Program

Stephen W. Wilson, Program Manager, Northrop Grumman Technology Services

Indianapolis Operations

Production System
Allan Swan, VP Operations, Rolls-Royce U.S. Defense Sector

Wes Sloan, Head of Operations Capability, Rolls-Royce

SUB-SYSTEM R&D/SDD

Adaptive Vehicle Management System
Jamie Dryfoos, AVMS Program Manager, The Boeing Co.

T408/GE38 Engine Program
Paul Acquaviva, Program Director, GE Aviation

Long Range Anti-Ship Missile (LRASM)
Mike Fleming, Program Director, Lockheed Martin Corp.

SYSTEM PRODUCTION

Data Repositories Program
Kristie Harris, Program Manager, Northrop Grumman Mission Systems Division

SUB-SYSTEM SUSTAINMENT

Ground-Based Midcourse Defense
Robert A. Green, Program Manager, The Boeing Co.

Secondary Power Logistics
Tim Van Luven, Sr. Director, USAF Programs, Honeywell Aerospace

SYSTEM R&D/SDD

Guided Multiple Launch Rocket System Alternative Warhead Engineering & Manufacturing and Development (GMLRS AW EMD)
Aubert Clanan, Program Manager, Lockheed Martin Missiles and Fire Control

SYSTEM PRODUCTION

Integrated Fixed Tower System
Joel Friederich, VP Public Safety & Home Land Security Systems, Elbit Systems of America

GPS IIF Satellite
Munzir Badawi, GPS Program Manager, The Boeing Co.

SYSTEM SUSTAINMENT

Army Prepositioned Stocks-Afloat (APS-3)
Kent R. Selby, Sr. Program Manager, Honeywell Technology Solutions Inc. (now KBRwyle)

H-60 Performance Based Logistics Program
Rod Skotty, President, Maritime Helicopter Support Co.

Northrop Grumman Autonomous Systems/ RQ-4 Global Hawk
Michael W. Jaggers, VP and Program Manager, Northrop Grumman Corp.

Boeing Captains of Industry
Richard Robinson, Director DLA Support Programs, Boeing Defense Space & Security

2016 Best *Next* Practices

TRANSLATING PROGRAM PROPOSAL TO PROGRAM REALITY

Aubert Clanan, Program Manager-GMLRS AW EMD, Lockheed Martin Missiles and Fire Control

Joel Friederich, VP Public Safety & Home Land Security Systems, Elbit Systems of America (alpha team and baseline index)

Kent R. Selby, Sr. Program Manager-Honeywell APS Afloat, Honeywell Technology Solutions Inc./KBRwyle (tracking key bid assumptions)

Richard C. Robinson, Director, DLA Support Programs/Boeing Captains of industry, The Boeing Co. (proposal turnaround and time to award metrics)

WHICH BEST METRICS, AND WHY?

Richard Benton, Javelin JV Vice President, Lockheed Martin Missiles & Fire Control (what happens when govt changes CPARS – and managing through it)

Glen Cushman, Program Manager-F-22 Training Systems, The Boeing Co. (metrics along the way to improving speed/ cycle)

Tim Van Luven, Sr. Director, USAF Programs/Secondary Power Logistics Solutions, Honeywell Aerospace (availability, reliability and quality linked to business systems)

Ron Struble, Program Manager Bell V-280 Valor, SpiritAeroSystems (shifting supply chain to "best delivery" metric)

INTEGRATING LESSONS LEARNED/BEST PRACTICES

Paul Acquaviva, Program Director-T408/GE38 Engine Program, GE Aviation (integrating lessons learned from both military and commercial engine programs)

Iris Bombelyn, Vice President, Protected Communications/ MUOS, Lockheed Martin Space Systems (setting the tone/ the book, movie, but the program always first)

Kristie Harris, Program Manager (Acting)-Data Repositories, Northrop Grumman Mission Systems Division (transitioning lessons learned into effort)

Patrick Lardieri, Chief Engineer and Fellow, National Cyber Range, Lockheed Martin (why "willingness is important and how to measure it)

Allan Swan, VP Operations, Rolls-Royce (create a rallying cry to succeed)

Slowing Down

Emirates and Turkish Airlines feel the pinch in their profit margins

Jens Flottau Frankfurt and Cathy Buyck Brussels

The big three Gulf carriers and Turkish Airlines have long been perceived as a dangerous threat to established legacy airlines in Asia, Europe and the Americas. But the latest trends at Emirates Airline and Turkish show that the fast-growing superconnectors are by no means insulated against external shocks.

In fact, their latest results are alarming. And if the trends continue, the four carriers could well have their steepest growth behind them for now. Turkish is even announcing a significant reduction in fleet size. The development is also remarkable in the context of the recent fierce dispute about alleged subsidies and market access—the pressure for competitors in Europe, the U.S. and Asia may now be somewhat reduced.

Emirates, the biggest of the three Gulf carriers and the only one to publish audited financial reports, warns it does not see signs of market improvement after posting much-deteriorated results for the first six months of its financial year.

Emirates has no plans to defer aircraft deliveries, including for Airbus A380s, despite a massive drop in profits.

TONY OSBORNE/AW&ST

"The bleak global economic outlook appears to be the new norm, with no immediate resolution in sight," Emirates Group Chairman and CEO Sheikh Ahmed bin Saeed Al Maktoum says. "Increased competition as well as the sustained economic and political uncertainty in many parts of the world have added downward pressure on prices as well as dampened travel demand."

The carrier, one of the fastest-growing and financially healthiest airlines worldwide, suffered a 75% contraction in net profit (to $214 million) in the first six months of its fiscal year to Sept. 30. Its net profit margin of 1.9% is far below the profitability levels enjoyed by North American and even some European carriers. And it burnt through about $2 billion in net cash in six months mainly to fund aircraft acquisitions.

While Emirates did not disclose precise yield numbers, the trend has been very negative: The airline unit's revenues dropped by 1% to $11.4 billion, despite a 9% increase in passenger numbers and an 8% increase in revenue passenger kilometers (RPK). Emirates also grew capacity by 12%, leading to a three-point drop in its load factor, which was a relatively low 75.3%.

The gap between capacity and demand could widen in the next six months: In the first half of the year, the carrier took eight more Airbus 380s and eight Boeing 777-300ERs, though it also retired 19 aircraft. The net result is a small reduction in aircraft to 248 units. However, in the second half it is due to receive 20 additional aircraft and so far plans to retire only eight.

"There are no plans to cut or slow down deliveries," an Emirates spokesperson says. "We constantly review our capacity deployment to ensure the best utilization of our fleet in order to serve customer demand." Developments at Emirates are closely watched by Airbus, as the airline is the current life insurance for the struggling A380 program.

The carrier identified three major factors for the deterioration of its results: the strength of the U.S. dollar, which affects its cost base, as the United Arab Emirates dirham is tied to it, while the shortage of hard currency in some African countries has forced the airline to consider withdrawing or reducing services; geopolitics; and the weak economic climate.

Turkish Airlines is now also deep in crisis mode and, judging by its fleet plans, it expects to remain there a long time. The carrier is making a sharp U-turn as far as expansion is concerned and is scaling down both its short-haul and, more significantly, its long-haul fleet in the coming years.

Revenue in the nine months fell 6.1% while total expenses increased 7%. Consequently, the carrier posted a $463 million net loss, compared to an $872 million net profit in the year-ago period. Following a first half deeply in the red, net profit in the third quarter took a 60.9% dive, to $184 million. Business and consumer uncertainty due to terrorist attacks in Turkey and Europe, the failed Turkish coup in July and subsequent political tension, and overcapacity in many markets are factors increasingly dampening the airline's performance and outlook.

The carrier's fleet will be reduced to 324 aircraft in 2017 and 320 in 2018, down from 333 at the end of this year. The number of narrowbody aircraft will be cut from 234 at the end of 2016 to 221 in 2017 and 217 in 2018. The number of widebody aircraft is still showing growth from 86 units now to 94 in 2017 and 2018. But Turkish will cut back its long-haul fleet in several steps by almost 30% to a mere 70 aircraft in 2023.

The company disclosed to the Istanbul stock market on Oct. 7 that it had decided to reschedule the deliveries of 92 Airbus A321neos, 65 Boeing 737-8s and 10 737-9s that were planned to enter the fleet in 2018-22. Turkish so far has not confirmed reports that it is grounding up to 30 aircraft, of which 12 Airbus A330-200s are allegedly already parked at Antalya Airport.

In 2017, Turkish Airlines is scaling down its capacity growth to just 1% and will even decrease seat production by 1% in 2018. As recently as August, the airline had still planned for 5% seat growth in 2018.

Over the first nine months of the year, Turkish recorded a systemwide 17.2% revenue-per-available-seat-kilometer (RASK) contraction (a drop of 15% excluding currency effects) and a 14.1% year-on-year decline in yield, or an 11.7% fall excluding currency effects. The airline increased capacity by 14.3% in the first nine months of the year, but traffic did not follow the same pace. RPKs grew only 8.2% year-on-year and passengers carried 3.9%, load factor suffered a decline of 4.2 percentage points to 74.5% systemwide. Last year, Turkish Airlines recorded a 12% increase in passengers carried.

Twin Thrusts

Propulsive and thermodynamic advances mark progress on Rolls-Royce advanced product plan

Guy Norris Los Angeles

ROLLS-ROYCE

Rolls-Royce has begun tests of a powerful gearbox and inaugurated a research site focused on high-temperature composite materials, both key steps toward its future vision of developing an all-new family of advanced very-high-bypass-ratio turbofan engines for the mid-2020s.

The two events mark major milestones on the company's strategic road map to developing a next-generation product family based on leaps in propulsive and thermodynamic efficiency. The plan will culminate in the UltraFan, an engine aimed at future airliners for 2025 onward and the first Rolls-Royce large commercial turbofan to incorporate a gear-driven fan.

Aimed at medium- and high-power applications up to the 100,000-lb.-thrust range, the UltraFan will have a very large, 15:1 bypass ratio and overall pressure ratio of 70:1. For the higher-thrust family variants this is expected to provide a fuel-burn improvement of at least 25% over the Trent 700. The gains in propulsive efficiency will come largely from development of a large, gear-driven lightweight fan, while thermodynamic gains in the core will derive from a higher-compression core incorporating advanced heat-tolerant ceramic matrix composites (CMC) and other new materials.

The gear system, developed by Rolls and made by joint-venture partner Liebherr-Aerospace, was produced in Friedrichshafen, Germany, and tested at the engine-maker's purpose-built power gearbox (PGB) evaluation facility in Dahlewitz, near Berlin. The first run—on the site's Attitude Rig, which runs the gearbox at various angles simulating climbing, banking and descending—confirmed rig dynamics and oil system functionality at low pressures and speeds, Rolls says.

The company, which cites earlier heritage gear drive system experience with turboprops such as the AE2100 and T56 and the lift fan for the F-35 Joint Strike Fighter, says gear tests will eventually reach up to 100,000 hp. "More advanced testing will take place during the rest of the year to provide additional data on low-power high-speed combinations at various pitch and roll angles and at different simulated altitudes. High-power testing will take place next year on the PGB Power Rig where the gearbox will reach full power," it adds.

Research and development of CMCs for hot-section components in the UltraFan is meanwhile stepping up in California, where the company officially dedicated a newly developed high-temperature composites research facility on Oct. 27. Based in Cypress, south of Los Angeles, the 62,000-ft.^{2} facility is already producing initial silicon carbide fiber-reinforced silicon carbide (Sic/SiC) matrix CMC test panels that will form the basis for next-generation components to be tested in future Rolls-Royce technology demonstrators. The unit, which employs just over 50 staff, is expected to grow to about 100 as work increases.

The core of the employees came from Hyper-Therm High-Temperature Composites Inc., a specialist engineering company based in nearby Huntington Beach that Rolls acquired in 2013.

Versions of the power gearbox under test in Dahlewitz, Germany, will feature in the UltraFan.

Rolls developed the facility in Cypress for planned expansion and began phasing over to the new site this April. The transition is due to be completed in November, when the old site will make its final batch of CMC products.

CMC components from the original Huntington Beach facility are running in the Advance3, an engine demonstrator that will pave the way for the Advance turbofan—a follow-on engine family to the current Trent that Rolls is targeting for development at the turn of the decade. Together with the PGB rig, the Advance3 demonstrator forms fundamental building blocks of the new family plan architecture. While the Advance core is the foundation for the follow-on Trent engine, it will also ultimately be married with the gear system to form the UltraFan.

Steve Richards, president and general manager of Rolls-Royce High Temperature Composites (HTC) and head of CMC programs at Rolls, says the facility will pave the way for methods of large-scale Sic/SiC CMC manufacturing. "The facility we came out of is 18,000 ft.^{2} and this is three times as large. We have only filled out two-thirds of the space, so there is expansion capability here. There are a number of components we are going to progressively march through, and the idea is we will standardize a method of manufacture so we can productionize that."

The Rolls-Royce CMC development "road map takes us through a lot of hot parts, starting with static structures," Richards says. These will be the simpler structures first, then more complex parts, but the goal is all the way through the rotating parts. We have

not committed exactly when we will get there for some of the products to get to first application."

Whereas initial CMC elements tested in Advance3 "went along for the ride," Richards says the true thermodynamic benefits of the material will be fully explored in follow-on demonstrators such as the High-Temperature Turbine Technology (HT3) program. The HT3 will be based on a Trent XWB-97 donor engine from the Airbus A350-1000 certification and test effort and follows on from the Trent 1000-based EFE (Environmentally Friendly Engine) demonstrator program. Initial CMC applications envisaged by Rolls include shroud segments and vanes, with progressively more complex applications as testing proceeds.

"We are making test panels here to build up and characterize the materials. The CMC in the Advance3 will not be the same one that goes into the next demonstrator," says Allan Jamieson, manufacturing engineering manager at Rolls-Royce HTC. "We are used to working in metals, but the manufacturing challenge here is that it is not written down, there is no guidebook, no reference. The control of the process will really make or break CMCs. You can have the best design and the best ma-

TECHNOLOGY

Out of Sight

NASA and industry tackle next phase of drone flight

John Croft Syracuse, New York

A salvo of increasingly complex tests of unmanned aircraft using newly developed air traffic management aids and conflict-avoidance tools for smaller unmanned air vehicles flying beyond-visual-line-of-sight (BVLOS) are uncovering the realistic factors that will affect large-scale multivehicle operations.

In a test of 11 different types of small unmanned aircraft systems (UAS) at Nevada's Reno Stead Airport in mid-October, NASA found that relatively small perturbations with major impact—like an unanticipated increase in wind speed or a wandering light general aviation aircraft—are helping to define how to manage disruptions. "If everything is working fine, there really is no need to have air traffic management," says Parimal Kopardekar, project manager for NASA's Safe Autonomous Systems Operations Project. "It's all about the ability to handle off-nominal conditions."

NASA's key contribution is a UAS traffic management (UTM) system architecture that allows for operators to submit a flight plan over the Internet and become a client in a real-time monitoring system that keeps operators updated on the status of the airspace.

The Reno test was part of what NASA is calling Development Capability Level 2 (DCL 2), the second of four DCLs designed to result in the ability of UAS operators to freely "file and fly" with their small vehicles in FAA uncontrolled and controlled airspace by 2020. The effort is being buoyed by a groundswell of activity from the FAA, NASA, private industry and academia, with demonstrations and research largely taking place at the FAA's six UAS test sites across the U.S., through its UAS center of excellence, a grouping of 22 research institutions headed by Mississippi State University and by companies such as BNSF and CNN, taking part in four "pathfinder" programs.

Through the Part 107 small UAS rulemaking published in August, the FAA now allows for line-of-sight operations with aircraft weighing less than 55 lb. at altitudes of 400 ft. and below in uncontrolled airspace (away from most airports), segregated from manned aircraft. However, operators must seek waivers to be able to take advantage of expanded capabilities,

AMAZON

Package delivery services, including Amazon's Prime-Air, will rely heavily on traffic management architectures being developed by NASA and industry.

including BVLOS and at night and in controlled airspace, regimes that commercial UAS operators will require to thrive.

As such, much of the near-term research is aimed at allowing operators to routinely access airspace with multiple aircraft with few or no restrictions compared to manned aircraft. The timeline is relatively tight, with the FAA expecting to issue a proposed rulemaking for BVLOS and expanded operations by the end of fiscal 2017, one year after Part 107 was finalized.

DCL 1, which ended with a test of 20 UAS flying simultaneously in line of sight at the six FAA test sites in April, proved that operators could successfully use a NASA-provided web-based interface, or client, to file a flight plan, which would then be accepted or rejected based on all submitted flight plans. The system then tracked the real-time position telemetry from the vehicles during the test.

During the DCL 2 test at Reno last month, all UAS flew BVLOS at some point during the demonstration of four operational scenarios (agricultural, lost hiker, ocean and earthquake), with at least two aircraft BVLOS of the pilot in command at any given time, says NASA. Each scenario featured five aircraft flying simultaneously. NASA says command and control of the aircraft remained with each operator's ground control station, but situational awareness and alerting was provided by each ground station's UTM client, which was connected to the NASA UTM research platform.

What researchers did not expect was the effect of vehicle performance degradations caused by hot and high conditions and increasing winds. "The density altitude can go up to 9,000 ft.," says Kopardekar. "The aircraft are working really hard to operate in that hot, high air, and on top of that, you hit headwinds. You're struggling to keep up." There was also a situation where a rogue aircraft—what Kopardekar described as a "Piper Cub that was going his merry way" out of radio communications and circling the range—disrupted the test. Kopardekar says a few of the unmanned aircraft were BVLOS at the time, but they were able to maintain separation based

ROLLS-ROYCE

Rolls-Royce's CMC research center in California will pave the way for mass production of high-temperature materials.

terials, but if you can't make it in the volumes for something like a Trent XWB, then it will limit the success of CMCs. So manufacturing is the key."

Tas Singh Purewal, Rolls-Royce chief of capability acquisition, says: "This facility represents our ability to take something that is innovative and new, and not just go through the challenges of designing those new materials but also use the latest state-of-the-art manufacturing technology. We have demonstrated that we can take a technology in its infancy and mature it through facilities like this in terms of preproduction."

on range surveillance on the Piper. "We need to expect the unexpected, particularly for non-cooperative aircraft," he says. Those lessons as well as other potential occurrences—delayed communications, radio malfunctions, "fly-aways," community noise, GPS- or cellular service-denied situations and cybersecurity—are on the broader to-do list.

Next steps for UTM and airspace research include BVLOS exercises at all six test sites, likely in about six months, and the culmination of efforts by several working groups to define or develop concepts of operations and "use" cases, data exchange protocols, detect-and-avoid capabilities, communication and navigation needs, UAS minimum performance criteria, electromagnetic spectrum needs and weather information requirements. Ongoing vehicle research areas include geo-fencing conformance, detect-and-avoid as well as track-and-locate capabilities, hazard avoidance, trajectory uncertainty, vehicle contingencies and needs for the "first and last 50 ft. of operations."

"All of this will culminate in a giant NASA and FAA UTM pilot project," says Kopardekar. "We're working with the FAA to define the content of that project."

About FACE

A conformance program aims for avionics software portability between aircraft

Graham Warwick Washington

A government-industry initiative to enable truly portable and reusable software for airborne applications has reached a milestone with completion of an ecosystem that extends from a technical standard for software design through conformance testing to a library for available programs.

Establishment of a conformance program for open software completes a plan launched more than six years ago by the Future Airborne Capability Environment (FACE) Consortium, which comprises the U.S. armed services, the major avionics suppliers and many of the smaller players.

Vanderbilt University's Institute for Software Integrated Systems has been established as the conformance authority and will operate the FACE registry, which will list software available for reuse that has been certified as conforming to the FACE technical standard.

The initiative tackles the perennial problem that software developed for one aircraft cannot be moved to another quickly and easily. Software certified as portable and reusable would reduce the time and cost to integrate new capabilities onto existing platforms.

FACE differs from previous open system standards in that software must pass formal verification testing to be certified as conforming with the technical "standard of standards," and is therefore fully portable and reusable between different platforms.

Creation of the conformance authority completes "version 1.0" of an ecosystem that includes the FACE reference architecture and technical standard, independent entities that conduct the verification testing, the conformance authority and the software registry.

"Announcement of the conformance launch means the FACE ecosystem version 1.0 is live and ready for business," says Judy Cerenzia, FACE Consortium program director at the Open Group, which leads the development of open information technology standards across industries.

"We have the technical standard in place. We have the business strategy in place, which is to enable a conformance program and a verification program, develop a business model that is attractive to both industry and government, define an acquisition approach to make FACE meaningful in competition . . . and make it successful for adoption by the avionics industry," she says.

Use of the FACE standard has already been required by the U.S. Navy for a C-130T avionics modernization by Lockheed Martin and the U.S. Army for the UH-60V cockpit upgrade under development by Northrop Grumman. The Army is also requiring FACE conformance for the planned Future Vertical Lift program.

Conformance is a key tenet of FACE, and differs from compliance with an open systems standard, says Kirk Avery, FACE technical working group chair and Lockheed Martin fellow. "Many operating-system [OS] developers can state they are Posix-compliant. But Posix is a large standard and compliant means for that, for the APIs [application programming interface] they choose to implement, they meet the standard.

"Three manufacturers can develop Posix-compliant operating systems. That does not mean that each chose to implement the same set of APIs from Posix," he says. "If somebody designs a piece of software using one of those operating systems, because the APIs could be different it doesn't mean they'll

have portability to take that software and move it between each of them."

In both the FACE standard and conformance, the operating system APIs are dictated. "We embrace Posix because it is a standard that is used prevalently across many domains. But we needed to normalize the APIs required to be within any FACE operating-system component so we could ensure portability of any software," says Avery. "That way I can develop software for vendor X's FACE-conformant OS, move it to vendor Y's FACE-conformant OS and know it will execute."

"Compliance implies partial conformance," says Cerenzia. "With the FACE conformance program, you are either fully compliant or you are not. We don't want extra APIs in there that will inhibit portability or interoperability. We also don't want any to be missing, for the same reason."

"It's a higher standard to reach, but it is necessary to ensure you have portability and reusability of software components," says Jeff Howington, vice chair of the FACE steering committee and software business development manager with consortium founding member and sponsor Rockwell Collins.

"FACE will help in reducing integration time, but it doesn't eliminate it," says James Davis, a researcher at Vanderbilt and vice chair of the FACE data architecture working group. "We are not saying software components built to the FACE standard are plug-and-play. But FACE does give the integrator tools to help them understand what the software does, so that they are able to integrate it into their system faster and with less cost."

NORTHROP GRUMMAN

Northrop Grumman's UH-60V digital cockpit upgrade for the U.S. Army's Sikorsky UH-60Ls uses FACE-conformant avionics.

Examples of software components from many different locations are flowing through the FACE development and verification pipeline. "We have two examples that have completed FACE verification. One of those comes from [Rockwell Collins] in the flight-management software product line," says Howington. The other is from the U.S. Army. "I expect to hear soon of software components that have completed both certification and entry into the registry," he says.

Vendors can choose whether their software is listed in the registry for potential reuse. "You can become certified without being listed in the library," says Davis. "But if a supplier chooses not to register, they cannot make any public claims that they are certified as conformant," says Cerenzia.

In addition to customers specifying FACE, companies such as Lockheed are using the standard internally to meet requirements for openness and modularity. "We have embraced FACE for our product lines, and have many programs that are implementing the architecture and infrastructure and deploying different units of compliant [pieces of software], regardless of whether there is a FACE requirement," says Avery.

FACE began with the U.S. Navy and was quickly embraced by the Army. The U.S. Air Force finally joined as a full sponsor in 2015, and efforts are underway to ensure compatibility between FACE and the service's Sensor Open Systems Architecture (SOSA) standard, which covers software, hardware and mechanical and electrical interfaces for intelligence, surveillance and reconnaissance systems.

"They are looking at the FACE standard as an enabler for the software portion," says Cerenzia. The Air Force and Navy have joint programs to interface and integrate the SOSA and FACE standards.

"The key thing is interoperability," says Avery. "How can you use units of conformance and infrastructures from one standard to another? One of the efforts the Air Force has ongoing is studies on how the two standards can interoperate so that you can use those software components across both, and they can communicate and coexist in one system environment or enterprise."

With software making up 80% of avionics, FACE is intended as a "living" standard that adapts to changes in technology. The technical standard is already at version 2.1, and 3.0 is in development. "As we have gone from 1.0 to 2.0 to 2.1, and now we're moving to 3.0, there have been many things industry and the government have brought forward to the consortium to make the standard broader and more robust," says Avery.

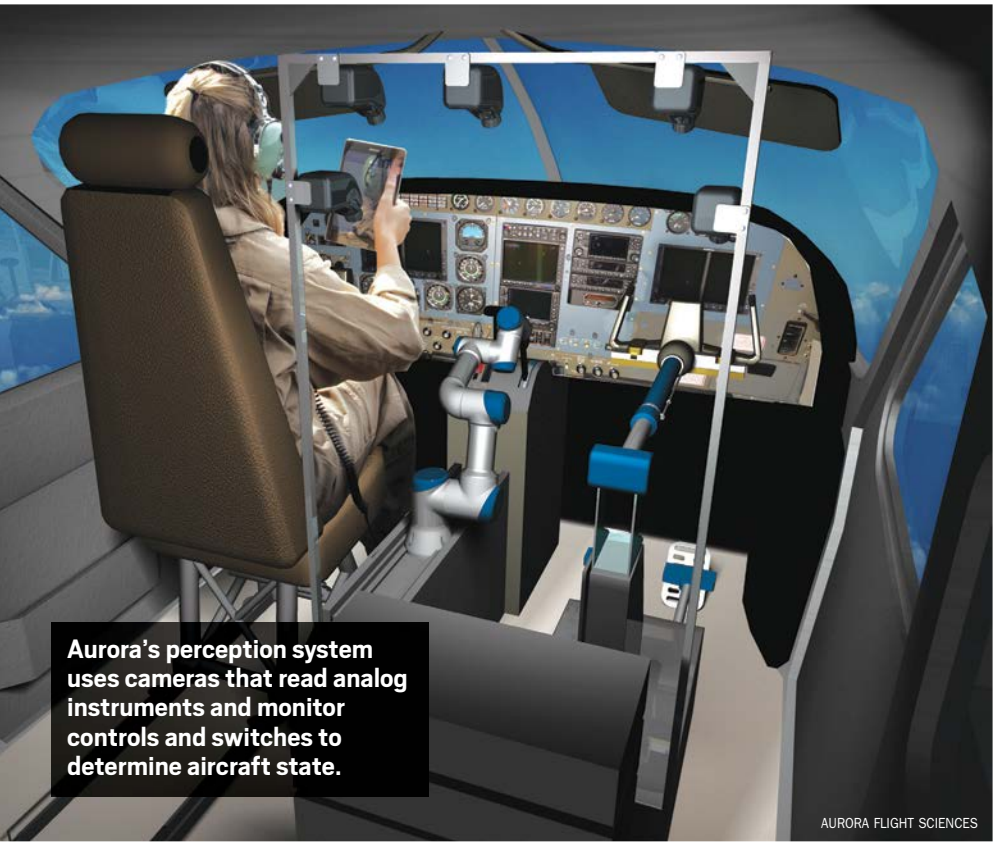
For version 3.0, that includes looking at how the data architecture associated with the FACE technical standard could be used by markets other than aviation. Citing the automotive and industrial control markets, Avery says, "The key attributes of FACE—portability, reuse, interoperability, develop once and use everywhere—are what other domains also long for. The ability to make systems more evolvable and manage obsolescence better—those are what the FACE standard will allow you to do."

Whichever rotorcraft it selects, the U.S. Army has adopted FACE for the Future Vertical Medium Lift mission system.

BELL HELICOPTER

Assisted by Autonomy

Demos suggest the path to autonomous systems on the flight deck is to improve safety first, reduce crew later



Aurora's perception system uses cameras that read analog instruments and monitor controls and switches to determine aircraft state.

AURORA FLIGHT SCIENCES

Graham Warwick Manassas, Virginia, and Poughkeepsie, New York

Unmanned technology is often portrayed as potentially replacing the pilot. But a DARPA program is showing how autonomy could be used to reduce workload and improve safety in existing aircraft, while at the same time building trust in automation to pave the way toward reduced crew sizes on certain missions.

Aurora Flight Sciences and Sikorsky conducted demonstrations in October concluding Phase 2 of the Aircrew Labor In-Cockpit Automation System (ALIAS) program. Both are bidding for Phase 3. ALIAS aims to develop a drop-in kit that can bring high-level automation to an aircraft and be moved between types.

As a DARPA program, ALIAS is focused on enabling reduced-crew operation of existing military aircraft. "Operating the same aircraft with fewer crew by making each human operator more efficient would help with the shortage of trained military crews and have a large payoff for the Defense Department," says program manager Dan Patt.

The program is about making a self-flying aircraft but not about eliminating the human, he says. "ALIAS can manage all the basic procedures so that the pilot is not flipping switches, but is able to use his time more productively." On a surveillance flight, says Patt, "the pilot could be thinking about the context of the mission and the information being collected versus managing the stick and throttle."

But the autonomy ALIAS brings to the cockpit goes beyond the military and could have near-term applications and long-term implications. Elements of the system could transition within five years, Patt says, but reducing commercial aircraft to one "mission commander" from two pilots "requires regulatory change, and generating enough data to prove it is as—or more—safe will take decades."

The ALIAS demos involved several technologies to bring autonomy to almost any aircraft, even those without avionics databuses. These range from camera systems reading analog instruments through robot arms moving controls to tablets allowing multiple users, on the ground and in the air, to collaboratively control the aircraft.

"We have this vision where automation can ultimately manage all the lower-level flight tasks. In the meantime, pieces of the technologies can make aviation safer with conventional crew operations," says Patt. He draws a parallel with the automotive sector, where there are safety concerns with self-driving cars but many of the individual technologies can make driving safer.

Aurora's perception system, with its ability to monitor gauges and alert the pilot, is "something you can imagine going into cockpits soon and improving safety without removing anybody," Patt says. The longer-term model for ALIAS "is automation that is capable of handling contingencies and can help triage all the complex information coming in and distill it into something that is human-understandable."

Aurora's ALIAS demonstration at its Manassas, Virginia, headquarters, involved flights of a DARPA-provided Cessna Caravan and ground demos in a second Caravan and a Bell UH-1 helicopter used as hardware-the-loop simulators. The program has also involved flights by Aurora's optionally piloted Centaur, a modified Diamond DA42 piston twin.

The cargo Caravan, from an unnamed commercial operator, was modified to add the perception system in the right side of the cockpit. This includes four cameras mounted to stare at the instrument panel and monitor the gauges, switches and controls. The system reads and digitizes needle and switch positions and feeds this aircraft-state data into ALIAS.

Replacing the right seat are pallet mounting actuators that move the control column and rudder pedals, and a six-degrees-of-freedom robot arm that engages to move the throttles and deploy the flaps. The pilot can disengage the arm quickly; it will also withdraw if it comes into conflict with the pilot.

Not implemented on the Caravan, but under development, is a speech recognition system enabling the pilot to interact verbally with ALIAS as he would with a co-pilot. "It will listen to air traffic control and feed that digitally into the system. It will listen to the pilot and do challenge-and-response, as a co-pilot does. And if you miss a step, it will remind you," says John Tylko, chief innovation officer.

Key to ALIAS is the knowledge it needs to fly an aircraft and that it must assimilate to adapt to a different platform. This includes a flight dynamics model and all the normal and abnormal procedures in the pilot's manual. "The hard part with programming a UAV is figuring out every state possible," says Patt. "With an existing aircraft, it is all written down in the manual. The autonomy just has to learn it."

Aurora's knowledge-acquisition system is based on generalized templates that take advantage of the fact that procedures are similar within classes of aircraft—single- or multi-engine, for example. "If it is a single-engine, fixed-gear aircraft, we do not need to know how to retract the gear. We can produce a generalized flight manual in significantly less time," Aurora says.

This knowledge was seen in action during the Caravan ground demo. After a simulated takeoff, the pilot engaged ALIAS using the tablet. The arm moved to grasp the throttle and the system took control of the aircraft. Using the tablet, the pilot commanded a 90-deg. turn; the system read the gauges and the arm moved the throttle up to maintain altitude.

Aurora then demonstrated how autonomy could help a disoriented pilot recover from an unexpected attitude through a rapid handover of control to ALIAS to stabilize the aircraft in level flight. The system's knowledge of the procedures in the flight manual was then demonstrated by simulating gearbox contamination leading to an engine failure.

The perception system saw the chip light illuminate, and was watching the oil pressure gauge. If pressure stays above a certain level, the manual says, the alert is not serious. But the system saw oil pressure decreasing and the low-pressure light illuminate. ALIAS alerted the pilot and brought up the engine-failure checklist on his tablet.

The pilot confirmed engine failure; the system brought the throttle back to idle and the aircraft to best glide speed. The pilot then went through the checklist, on which some tasks were assigned to ALIAS. The perception system monitored the pilot's actions and cockpit indications to verify checklist items had been completed, and it prompted him if required.

The perception system is installed in the Centaur and Huey, and Aurora says all ALIAS hardware and software is identical across the Caravan, DA42 and UH-1, showing its extensibility to different platforms.

The rival ALIAS demonstration involved the Sikorsky Autonomy Research Aircraft (SARA), an S-76B converted to an optionally piloted vehicle, another Caravan and a ground-station van. The demo was at Poughkeepsie, New York, home of AAG, a Sikorsky subsidiary providing fractional shares in S-76s.

Modified to fly by wire under Sikorsky's Matrix Technology autonomy program, SARA represents one end of the ALIAS application spectrum. The DARPA-provided Caravan, from the same commercial operator, is toward the other end, its existing autopilot actuators modified to work with the system.

The demo simulated a cargo mission—"one of the simplest," says Igor Cherepinsky, Sikorsky director of autonomy programs. The concept of operations was to create "one big cockpit," with ground and aircrew operating as a team, all using the same tablets, on a network, to manage the aircraft via the autonomy system.

Actuation is different, and control laws modified, but autonomy software is identical between Sikorsky's S-76B SARA and Cessna Caravan.

SIKORSKY

SIKORSKY

The pilot controls SARA through a tablet. The same tablet is used to fly the ALIAS-equipped Caravan.

Capable of flying fully unmanned, SARA has full-authority digital flight controls and triple-redundant autonomy mission managers. The Caravan has dual mission managers. Because ALIAS flies the turboprop via its existing autopilot servos, its flight-control authority is limited to 50-80%, Cherepinsky says. The high-performance computing hardware differs, but the two aircraft run the same software.

The goal of Sikorsky's demo was to show the pilot could fly a cargo mission in the helicopter, land, take the same tablet and attach it to the instrument panel of the Caravan, then take off and fly a cargo mission using the same hardware and software. A second crewmember flew as safety pilot on both.

In SARA, the pilot operates the helicopter via the tablet on his kneepad. The mission is planned on the touch screen, and tasks are allocated between pilot, ground operator and ALIAS. A six-degree-of-freedom SpaceMouse mounted on the right windowsill allows the pilot to "bump" aircraft position, making terminal-area operations easier, but the commands still go through the autonomy system.

When a mission or command is input, and throughout the flight, the path-planning system automatically checks the route ahead for any obstacles detected by lidar sensors onboard SARA. Within constraints set by the autonomy mission manager, the system then automatically adjusts the plan to avoid collisions.

A mission plan is built up from goal points. "A goal is assigned to each point in space," says Cherepinksy, and the autonomy system knows when it can deviate from that goal, by how much, and still fulfill the mission. "If you tell it to 'land at' and it cannot, it bubbles up to the operator," he says. "If you tell it to 'land near' and it cannot, it finds a good site and tells the operator 'If you do nothing, I will land here.'"

In the demo, SARA taxied out manually. The ground station commanded takeoff, and the S-76B lifted autonomously to a 40-ft. hover, where the lidar sensors began scanning, generating a hazard map on the tablet, conflicting terrain in red. Cherepinsky then showed how the tablet can be used on the ground to reposition the helicopter by touching the map display.

Tablets are connected to the ground station by Wi-Fi, and via the ground station to the aircraft by a commercial communications link using a steerable antenna. "We use the data link's encryption, and ours on top," says Cherepinksy. A high-capacity link is needed to share the lidar data. Commands take less bandwidth, and SARA can be controlled beyond line of sight using a low-rate Iridium satcom link.

Via the network, the pilot's tablet shows commands as they are entered by another user. He can press an "execute" button to accept the changes, or "abort" to reject them. Control of the aircraft is transferred verbally because that is how the U.S. Army performs the cargo mission, but it works seamlessly, he says.

After takeoff, the pilots did not touch the controls. "ALIAS can take the aircraft all the way to the ground," says Cherepinsky. After landing, and manually taxiing back to the ramp, the crew transferred to the Caravan and, following a manual takeoff, control was handed over to the ALIAS tablet.

Where SARA is a pre-existing asset, the Caravan was provided to demonstrate portability and "represents what we can do in two months," he says. Between them, the two aircraft "show how we can provide a spectrum of applications and not just a one-size-fits-all approach."

As required for ALIAS, the Caravan demonstrates the robotic control required in an aircraft that lacks an autopilot. An electromechanical actuator in the pedestal drives a claw that clasps and moves the throttle, while another moves the flaps under control of the autonomy system.

Sikorsky is not putting any emphasis on the robotic system but has installed cameras in the Caravan's cockpit to collect data to develop the capability to read the analog gauges and switches and is working on speech recognition, says Cherepinsky. A UTC Aerospace Systems lidar and short-wave infrared sensor has since been installed to bring in collision avoidance.

Sikorsky's ALIAS implementation concept ranges from a "distributed solution" that provides highly reliable and ballistically tolerant "always on" augmentation—but involves modifications at several locations around the airframe—to an "integrated solution" where everything is in the cockpit.

With the distributed approach, it will take 200 hr. or more to retrofit each aircraft and about a year to adapt ALIAS to a new platform. The integrated system can be adapted rapidly and retrofitted quickly, in a day to a week, but provides only "autopilot-like" reliability and is not full-authority. "The Caravan is somewhere in between," says Cherepinksy.

Both companies have submitted bids for Phase 3 of ALIAS, which will mature selected technologies and includes flying them on another, different platform. Patt says DARPA has a transition partner, which remains unidentified.

Aurora's bid focuses on perception and speech recognition, and not robotic actuation. "We have learned what the community is prepared to accept," says President and Chief Operating Officer Mark Cherry. "Near-term, pilots are not ready for actuation. They are ready for perception, checking, speech recognition and reading back checklists."

Sikorsky's strategy for Phase 3 "is centered around transition to the field and qualification. Focused technology advancement would continue and center on additional intelligence, planning and man-machine interface capabilities," says Cherepinsky.

Technologies demonstrated by ALIAS are key to more robust cockpit automation and, long term, "could fundamentally change the way people interact with aircraft," Patt says. It is hard to break out of a paradigm, but this might be the way to introduce this technology to flight. "What is clear is that the cockpit of the future for a single-crew or self-flying aircraft cannot look anything like today's."

Check 6 *Aviation Week editors debate the promise and the peril of aircraft under robotic control:* **AviationWeek.com/podcast**

Remaking the King

U.S. Army and Navy retool King Air simulation and training

John Croft **Dothan, Alabama, and Corpus Christi, Texas**

At the U.S. Navy's T-44C training center in Corpus Christi, Texas, a facelift two years ago of the multiengine simulation and training program is now producing better-prepared students for fleet replacement squadrons (FRS) and increasing the simulated-to-live flight training ratio. The T-44C is the Navy's designation for the Beechcraft King Air 90 twin-engine turboprop.

At the Army's Dothan training center in Alabama, where an overhaul of the C-12 (King Air 200) multiengine training will go operational in March, officials expect similar benefits.

CAE PHOTOS

Navy multiengine trainee pilots exit one of six CAE-built T-44C flight simulators at the Navy's Corpus Christi, Texas, training center.

While the flight needs of the two services could not be more dissimilar, the expectation for positive results through simulation and training upgrades has two factors in common—both take advantage of technology refreshes and both have CAE at their core. The Montreal-based simulator manufacturer and training provider has seven-year contracts with the Army and Navy to operate their multiengine training programs in part with new simulators, and in the Army's case, with new entry-level training aircraft.

From a broader perspective, the new training systems could allow the military to further increase the cost-savings attained with simulators versus live flight when that transfer results in a net gain in the proficiency of the pilot or other aircrew. Officials do not take the tradeoff lightly. "You can step over that line of creating tactical wizards who cannot fly their way out of a paper bag," says Rear Adm. Dell Bull, the Navy's Chief of Naval Air Training (Cnatra) of the simulator versus live-flight ratio. Approximately one-third of all flight hours per year are dedicated to training using approximately one-fourth of the Navy's aircraft.

For its multiengine training track at Corpus Christi—where the Navy trains about 400 T-44C pilots per year, most of whom will fly the E-2 Hawkeye, P-3 Orion and P-8 Poseidon—CAE is operating two FAA Level 6 "unit training devices" (fixed-based simulators with no visual system) and four FAA Level 6 flight-training devices with visual systems.

Training takes approximately 100 days, 60% of which is spent in the classroom, 16% in the simulator and 24% in a fleet of 54 T-44Cs owned and maintained by the Navy. CAE owns the simulators and provides the simulator instructors. New pilots are initially trained in the single-engine T-6 turboprop, starting with classroom and simulator training in FlightSafety International simulators, taught by instructors working for defense contractor Cubic Corp. Active duty military pilots, mostly with the Navy and Marine Corps, provide the live flight instruction.

For the T-44C program, the simulator-to-live flight ratio is approximately 42%, but the number is trending upward. For the P-3 and P-8 programs, the Navy has identified as many as 11 live training flights out of a total of 38 that can be moved to the simulator. Included is an intermediate stage check that students must pass to continue to the next phase of training. Other live flights that can potentially be moved into the simulator include instrument flying and Naval Air Training and Operating Procedures Standardization program checks, says Phil Kruse, CAE's program manager for the T-44C.

It is too soon to tell how much extra King Air training the Army will be able to transfer to simulators, since the new program does not officially begin until March when CAE takes over from the previous provider, FlightSafety. CAE last year won a contract from the Army to provide initial and recurrent in-aircraft and simulator training for pilots who fly the Army and Air Force C-12s. The Army uses the C-12U model, which features a Rockwell Collins Pro Line 21 cockpit; the Air Force uses the C-12V model, with a Universal Avionics EFI-890-based cockpit.

CAE will offer seven courses, four for Army pilots—initial fixed-wing training in a Grob 120TP single-engine turboprop trainer, C-12 aviator initial qualification (AQC), C-12 instructor qualification and C-12 refresher training—and three for the Air Force: C-12 AQC, C-12 instructor qualification and C-12 re-

CAE has purchased six Grob 120TP single-engine turboprops for entry-level fixed-wing training for Army King Air pilots.

fresher training. About 600 pilots per year will use the training center, with refresher training taking approximately one week and transition courses taking about three months.

The curriculum for Army helicopter pilots transitioning to the C-12 will include live flight training on six Grob G120TPs, owned and serviced by CAE, and 10 C-12U King Air twin-engine turboprops. Army pilots must receive training in the Lakota helicopter before selecting the fixed-wing track. Grob training will take place in two Frasca simulators, while C-12 training will be conducted in four CAE full-flight simulators, two of which have "roll-on, roll-off" cabs (for variants of the C-12 cockpit) that can be mounted to the same motion platform. CAE is providing the simulator and in-aircraft instructors for both the Grob and the King Air.

A key feature of the CAE program is the shift from the succession of four training aircraft in the FlightSafety program—the Cessna 182, Zlin 242L (for upset prevention and recovery), Beechcraft B55 Baron and King Air—to two aircraft, the Grob and the King Air, both of which are turbine-powered and have glass cockpits. Scott Wagner, director of operations and training for CAE's Dothan Training Center, says "many" of the FlightSafety instructors will be joining the CAE team; however, the existing fleet of King Airs will not be used for the new program. Instead, the Army is refurbishing 10 previously owned King Air 200s into the C-12U and C-12V configuration for the program.

Given the financial pressures to do more with less, the Army and Air Force will no doubt be evaluating the simulated versus live-flight ratio of the Dothan program compared to its predecessor once the pilot pipeline begins to flow. Lessons learned from the Navy at Corpus Christi could help. While officials do not plan to reduce the overall amount of training, their desire is to be able to move training currently taking place in the FRS to Corpus Christi, backfilling the time with new FRS tasks.

Such shifts have to be done on a case-by-case basis, however, and only when such a move makes sense. "For jets, you need more time in the aircraft due to the G Forces," says Wil Merkel, simulator requirements officer for Cnatra. "But for multiengine aircraft, you don't need the motion." He says a 50-50 ratio is possible "eventually," although there are some training programs in which the ratio will be lower. "We want people at the introductory level [in certain tracks] to experience those flight dynamics," he says.

Simulators can be uniquely advantageous even without such dynamics. Capt. Bennie Sanchez, Cnatra's deputy chief of staff for operations, says pilots, despite knowing they are not going to crash, become completely immersed in a simulated flight, particularly when anomalies are introduced. "The threat of failure is a big motivator," he says.

From a scientific standpoint, instructors in the simulator are able to probe the edges of a pilot trainee's saturation point, ensuring that the pilot will revert to first principles to resolve the crisis. "In aircraft, you generally get there by mistake," says Sanchez. "In the simulator, you can work up to that point and train the response. You can fall back to basics."

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Simulator Strategies

Airframers add enhanced simulator models to meet impending training requirements

John Croft **Washington**

Airbus and Boeing are revamping simulators and training programs to address a variety of aircraft handling deficiencies by pilots ahead of an FAA mandate in March 2019.

The so-called flight training rule, finalized by the FAA in 2013 in the wake of a series of fatal accidents including the 2009 Colgan Air/Continental Connection Bombardier Q400 crash near Buffalo, New York, calls for airlines to provide pilots with enhanced training in aerodynamic stalls, wind gusts, bounced landings, icing and upset prevention and recovery training (UPRT) skills starting in March 2019.

The training is to take place in full-motion simulators, which must be upgraded with enhanced models to accurately emulate aircraft performance and handling at or beyond the aircraft's stall angle of attack, a requirement not previously placed on simulators. The requirements are codified in new Part 60 simulator rules published earlier this year, which also call for the devices to incorporate an instructor's workstation that shows the validity of maneuvers with respect to the expanded envelope of the simulator. Airlines in many cases are developing their own enhanced training programs or extended aerodynamic models that meet FAA guidelines, but they can also turn to airframers and simulator manufacturers for help with the upgrades.

Airbus is particularly concerned about the fidelity of the simulators and the potential for "negative transfer of training," a situation that can occur when pilots learn skills based on a simulator operating outside of its validated envelope. The textbook example of the unintended consequences of negative training was the 2001 crash of American Airlines Flight 587. After

taking off from New York's John F. Kennedy International Airport, the first officer used "unnecessary and too aggressive" rudder inputs and snapped the vertical stabilizer, according to the NTSB final report. The carrier's simulation-based Advanced Aircraft Maneuvering Program, which did not realistically mimic the aircraft's motion in wake turbulence, contributed to the pilot's actions.

Marc Parisis, Airbus's vice president of training and flight operations, says that along with enhanced aerodynamic models for stall recoveries, the company is also developing its own "maneuver-based exercises" and "macro scenarios," including windshear events that instructors will be able to select at the instructor station to carry out maneuvers and scenarios called for in the FAA rule. Parisis, speaking at the Air Line Pilots Association Safety Forum in late August in Washington, said the enhanced models and scenarios for all Airbus aircraft types would be ready by year-end.

BOEING

"Today we do not have any scenarios at simulator manufacturers that have been validated by Airbus," he says. "We have even written to some simulator companies that we disagree with the scenarios." One manufacturer was using a scenario in which the instructor could introduce an upset situation that would bring the aircraft "quite rapidly" from cruise attitude to an angle of attack of 25 deg. nose-up without changing the flightpath, virtually impossible from a physics standpoint, he notes. "It's not realistic, and it's not recoverable," he says.

Included with the models will be simulator software for a more accurate stall buffet, the rumbling of airflow over the wing as the aircraft nears the stall angle of attack. For the A320, Parisis says there is no audio alert for an impending stall at high altitude, hence the buffet is a key indicator. Airbus previously had been providing data to simulator manufacturers on the buffet characteristics, but Parisis says the airframer was "not satisfied" with a sampling of those models.

"Our decision starting at the end of the year is that we will no longer provide the data but we will provide the simulation software," he says. "That means we will provide a specific software package so that when the simulator generates the input angle-of-attack and Mach number, we will provide the outputs for the buffet."

As for pilot-induced upset scenarios, which were at the root of both the Colgan and Air France Flight 447 accidents, Parisis says simulator scenarios should attempt to "startle and surprise" pilots in order to distinguish inappropriate actions from correct responses. Like Boeing, Airbus operates a network of training centers globally, including one in Miami. The idea is to highlight monitoring and awareness for early recognition and recovery of an impending upset, with the pilot-monitoring using standard callouts and possibly taking over control from the pilot-flying using the priority switch, a feature of the fly-by-wire Airbus side-stick control system.

He cited an incident in early August in which the pilot-flying of an Airbus aircraft in cruise flight made an inappropriate input when the aircraft momentarily exceeded its maximum speed due to a slight change in wind. "The pilot-flying's reaction was to go full back on the stick," says Parisis. "The pitch attitude went to 18 deg., and the pilot-monitoring did not take over."

Parisis says the short-term solution to such problems is for the pilot-monitoring to take over, but the long-term solution is to mitigate the startle response for the pilot-flying. "You have to have pilots be confident in their own skills to manage these events," he says. "Flying an envelope-protected aircraft is not an excuse for not having basic flying skills. The pilot has to take over when there is an issue, so he or she needs more simulator training in manual flying skills."

John Steinnes, Boeing's 737 fleet manager, is developing the fleetwide extended envelope and UPRT programs to be used in the company's simulator training operation. Boeing operates more than 38 full-motion simulators and has a staff of 450 Boeing and contractor instructors. "It is a huge effort for us to develop the courseware and curriculum and to modify the simulators for extended envelope training," says Steinnes, adding that Boeing is spending $20 million on the effort, including training for the 450 instructors.

Like Airbus, Boeing is developing extended aerodynamic models and scenarios for in-house training programs and customers.

"We are in the process of developing our programs now and hope to have our instructors trained by the end of 2017 or possibly halfway through 2018 to get ahead of the deadline in 2019," says Steinnes. He says that Boeing is integrating the extended envelope and UPRT into its full transition course "starting from Day 1." The course will include human factors "soft skills," stalls, recovery techniques and scenario-based training.

Steinnes says engineers at the company's research center in Russia are studying motion cueing in the simulator, analyzing eye-gazing techniques, developing an assessment tool to determine how well pilots are learning, and researching incidents and accidents to devise 20-25 scenarios for Boeing's scenario-based training.

With time getting relatively short for airlines to put in place the enhanced pilot training, Steinnes says Boeing is beginning to get requests "on what we are doing" and how to train pilots. "Some want to hit the 'easy' button and asked if there's something we can give them," he says.

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Future Events

Jan. 25-26, 2017—MRO Latin America. Cancun, Mexico.

Feb. 2-3, 2017—Aero-Engines Americas. San Antonio.

Feb. 8-9, 2017—MRO Middle East. Dubai.

March 2, 2017—Aviation Week Laureate Awards. Washington.

March 8-9, 2017—MRO East Asia. Seoul.

March 13, 2017—SpeedNews 7th Annual Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.

March 13-15, 2017—SpeedNews 31st Annual Commercial Aviation Industry Suppliers Conference (ASC). Beverly Hills, California.

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Nov. 28-29—Military Logistics and Procurement Kuwait. Radisson Blu Hotel. Salwa, Kuwait. See militarylogisticsprocurement.com

Nov. 29-30—SMi Group's Military Airlift and Air-to-Air Refuelling Conference. Grand Hotel Mediterraneo. Florence, Italy. See smi-online.co.uk/defence/europe/Military-Airlift-and-Air-to-Air-Refuelling

Dec. 1—International Air Transport Association Aviation Day Brazil. Brasilia, Brazil. Venue to be announced. See iata.org/events/Pages/aviation-day-brazil.aspx

Dec. 3-April 8, 2017—AOPA Flight Instructor Refresher Course. Various Locations. See aopa.org/forms/event-calendar/FIRC_ONSITE

Dec. 6—EMP/GVF High-Throughput Satellite (HTS) 2016 London Roundtable. The Strand Palace Hotel. London. See uk-emp.co.uk/current-events/hts-london-2016/

Dec. 6—Defense Strategies Institue Space Resiliency Summit 2016. Mary M Gates Learning Center. Alexandria, Virginia. See space.dsigroup.org/

Dec. 6-7—American Aerospace & Defense Summit 2016. We-Ko-Pa Resort & Conference Center. Scottsdale, Arizona. See aadsummit.com/

Dec. 6-8—Middle East Business Aviation Association (MEBAA) Show. Dubai World Central. Dubai. See mebaa.aero/

Dec. 8-10—International Conference on Annual Astronomy and Astrophysics Congress. Doubletree by Hilton Hotel Dallas. Irving, Texas. See eventbrite.com/e/international-conference-on-annual-astronomy-and-astrophysics-congress-tickets-22156262979

Jan. 9-13, 2017—4th AIAA Sci-Tech Forum and Technical Conferences. Gaylord Texan. Grapevine, Texas. See aiaa-scitech.org

Jan. 30-31, 2017—Maritime Reconnaissance and Surveillance Technology 2017. Crowne Plaza Rome St. Peter's Hotel & Spa. Rome. See https://www.smi-online.co.uk/defence/europe/Maritime-Reconnaissance

Jan. 31-Feb. 2, 2017—International Military Helicopter 2017. Venue provided after registration. London. See militaryhelicopterevent.com

Feb. 8-9, 2017—CAPA India Aviation Summit, Mumbai. The Leela Mumbai. Mumbai, India. See capaevents.com/ehome/index.php?eventid=198800&

Feb. 8-9, 2017—National Aviation Infrastructure Show. Crocus Expo. Moscow. See nais-russia.com/en/Home

Feb. 13-16, 2017—Pacific Northwest Aerospace Alliance 16th Annual Aerospace Conference. Lynnwood Convention Center. Lynnwood, Washington. See pnaa.net/events/annual-conference/2017-conference

March 5-7, 2017—ISTAT Americas 2017. Hilton San Diego Bayfront. San Diego. See istat.org/p/cm/ld/fid=49

Obama Passed on Space Issues

NASA

BY SCOTT PACE

China recently launched its second space laboratory, a man-tended module that currently houses two astronauts. The country is working toward a full space station of roughly 60 metric tons by 2022 and is actively courting international participation. Some in the U.S. debate whether or not to cooperate with China. The Chinese frankly don't care; they are seeking other partners. In space, as in so many other areas of international leadership, the Obama administration's decisions have resulted in a diminished role for the U.S.

The U.S. remains a space power second to none, but it is also more dependent on space—economically and militarily—than any other country. A strange inversion of space policy leadership has occurred in the last seven years. The White House has become less relevant, while the role of Congress has increased. Space is one of the few issues that is usually bipartisan. There have been exceptions, such as the fictitious missile gap in the 1960 election or debates in the 1980s over the Strategic Defense Initiative. Most recently, however, the most serious clashes have been between Congress and the White House, not Republicans and Democrats.

> "In the absence of a White House that cares about U.S. power and leadership, Congress will need to fill the vacuum."

In 2010, there was a bipartisan congressional revolt against the Obama administration's effort to cancel government-led human spaceflight and reduce NASA to a smaller science and technology agency. The cancellation of the Constellation program, particularly the goal to return to the Moon, was a shock to NASA, industry and U.S. allies. The administration continued to push away partners, telling Europeans to go to the Russians for their next robotic science mission. Plans to send astronauts to Mars orbit or a distant asteroid failed to find international partners. Today, it is increasingly hard to hold the International Space Station partnership together when no one knows what is supposed to come next.

Congress created a new, if awkward, consensus around Orion and the Space Launch System, essentially an improved Constellation crew vehicle and heavy-lifter, but without the Ares 1 to provide a safer alternative for crewed missions and a smoother transition to heavy-lift vehicles. With the objective of returning to the Moon gone, the Obama administration doubled down on government funding of "commercial" crew vehicles and set aside the momentum to build a dramatically safer launch vehicle after the space shuttle Columbia accident.

But it was not just exploration that saw a fading of administration interest. The White House punted on a whole host of civil, commercial and military space issues and left Congress to fill the vacuum. GPS spectrum has been under attack for years by the Federal Communications Commission, seeking more mobile bandwidth, and the White House has largely left its defense to the agencies. Commercial remote-sensing licensing has stalled even as U.S. companies are ever more innovative. The National Oceanic and Atmospheric Administration is conducting a pilot effort to use commercial data but only under congressional pressure. Similarly, it has been congressional pressure that has brought attention to a long-festering issue of the U.S. use of Russian rocket engines.

In the face of growing Russian and Chinese counterspace weapons demonstrations, the White House deserves some credit for putting new money and attention on space defense and resilience—a topic too long neglected by prior administrations. Hopefully, this effort will survive transition with congressional support. But there remains a more fundamental lack of strategic vision for space given its critical importance to U.S. national interests. Does the U.S. want to be a leader in space-based information services? Then it needs a regulatory process that supports innovation while protecting crucial utilities like GPS. Does the U.S. want to have greater depth and resilience in national security space systems? If so, it needs to organize, train and equip its armed forces to realistically operate under combat conditions. Does the U.S. want to shape the international norms of behavior in space? If it does, then it must lead projects in which other nations gain a stake in protecting a stable international order.

These are not separate ideas to be parceled out to separate agencies but complementary aspects of U.S. national power. In the absence of a White House that cares about U.S. power and leadership, Congress will continue to fill the vacuum. The Trump administration has a historic opportunity to forge a new partnership with Congress and create a better future for America in space.

Scott Pace is a professor of the practice of international affairs at the George Washington University and the director of its Space Policy Institute.

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