More Problems for Airbus's A380

RICH MEDIA EXCLUSIVE

Factories of The Future

Raytheon's CEO on The Next Technologies

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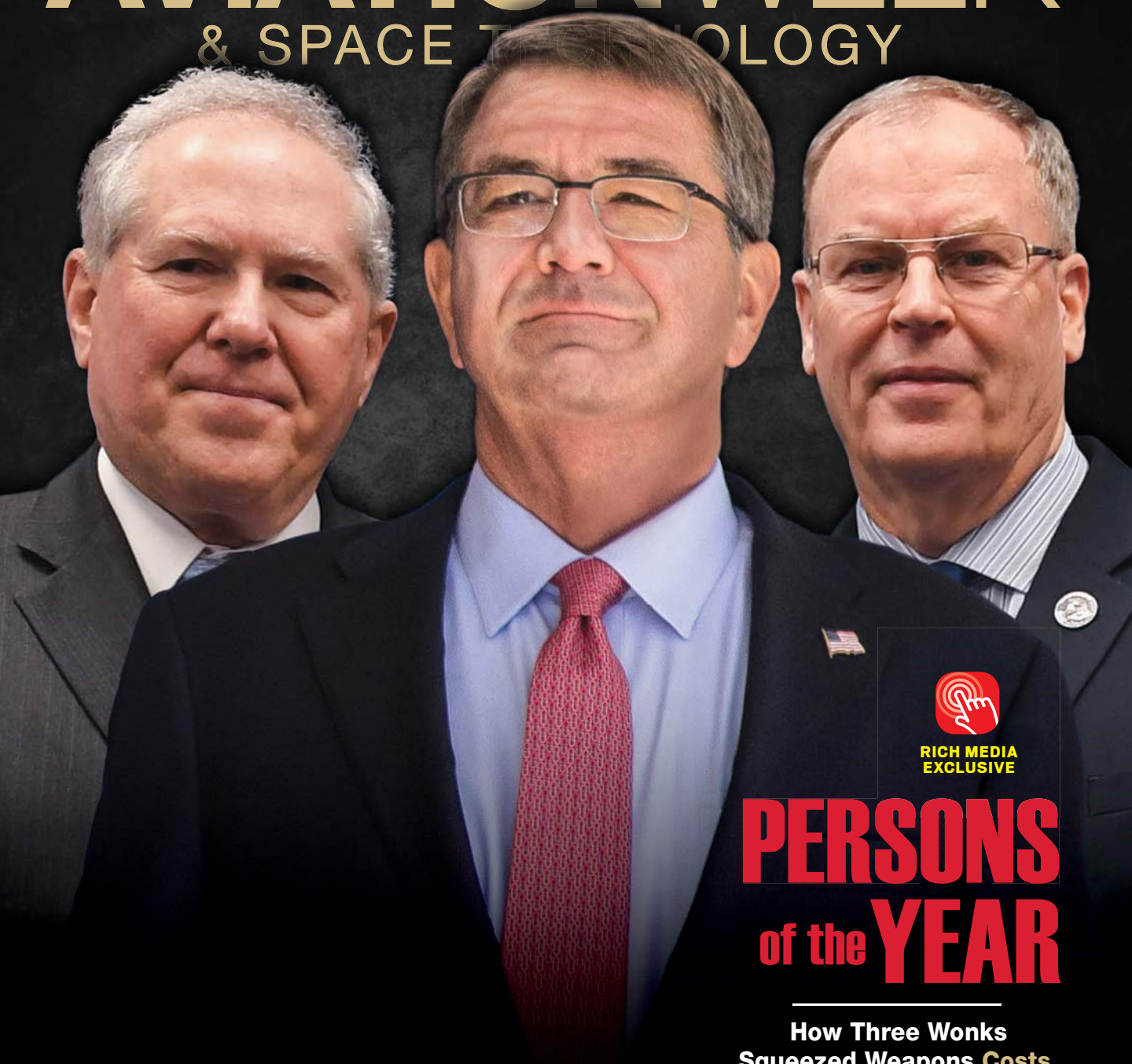
AVIATION WEEK & SPACE TECHNOLOGY



RICH MEDIA EXCLUSIVE

PERSONS of the YEAR

How Three Wonks Squeezed Weapons Costs, Kick-started Technology and Revved Up the Pentagon

AVIATION WEEK NETWORK

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January 9-22, 2017

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Volume 179 Number 1

AVIATIONWEEK & SPACE TECHNOLOGY

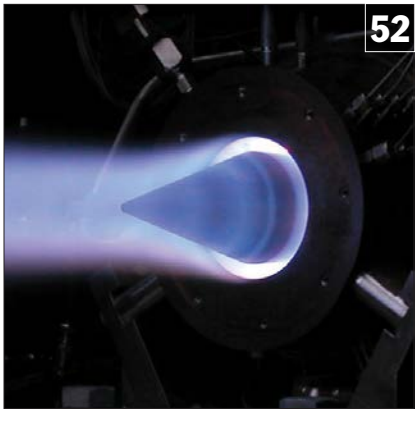
Digital Extras *Access exclusive online features from articles accompanied by this icon.*

20 *Canada at last made a selection for its Fixed-Wing Search-and-Rescue competition, awarding the C$2.4 billion contract to Airbus for 16 C295W aircraft and five years of in-service support.*

DEFENSE

SPACE

COMMERCIAL AVIATION



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AIR TRAFFIC MANAGEMENT

PERSONS OF THE YEAR

TECHNOLOGY

MANUFACTURING

ON THE COVER

Pentagon leaders Frank Kendall (left), Ash Carter (center) and Bob Work have worked together closely to drive down procurement costs, infuse new technology into systems and get weapons into the field faster. For that, they are Aviation Week's Persons of the Year (page 28). Defense Department photos. Elsewhere in this issue: The future of the A380 (p. 23), aerospace factories of the future (p. 44) and face to face with Raytheon's CEO (p. 48).

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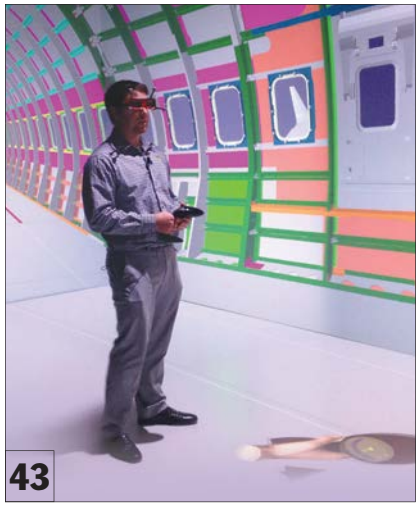

FACE TO FACE

ADVANCED PROPULSION

FROM THE EDITOR

BEHIND THE SCENES

***For our annual feature** on who had the most impact on the industries we cover, we talked with Ash Carter, Bob Work and Frank Kendall—the three top U.S. defense officials, whom we named "persons of the year." Here, Pentagon Editor Lara Seligman and Senior Business Editor Michael Bruno interview Carter, the defense secretary, in his Pentagon office.*

AIR FORCE STAFF SERGEANT JETTE CARR/U.S. DEFENSE DEPARTMENT

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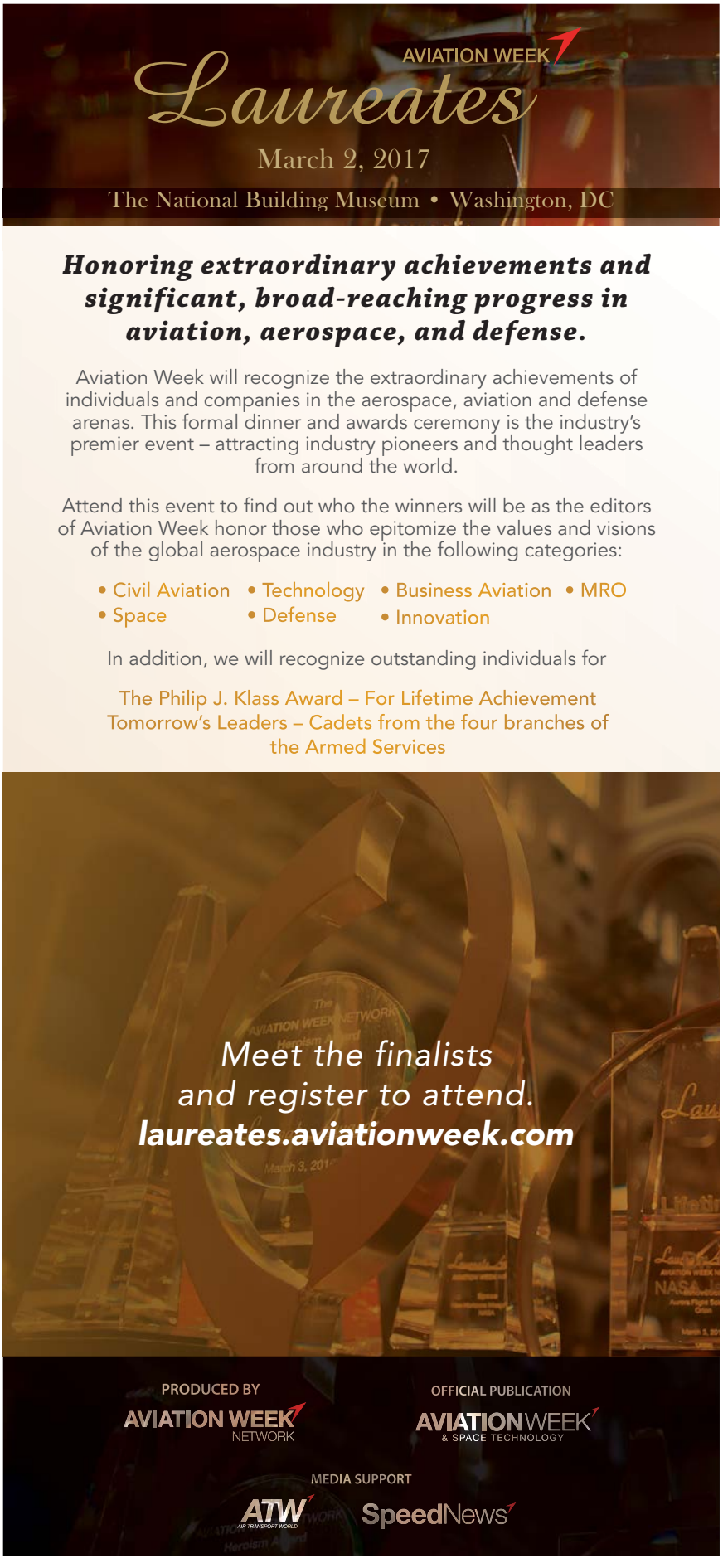

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Feedback

MIGUEL SUAREZ

IN 'HIND' SIGHT

I enjoy your photo issue every year and this year is no exception, but I did note a small error accompanying the caption of Miquel Suerez's wonderfully unique shot of a "vaguely alien-looking" helicopter (*Dec. 5-25, 2016, p. 67*).

The rotorcraft pictured is not the Mi-35 as captioned, but in fact is a Czech air force Mi-24 (Hind) in service with the 221st "Tiger" squadron, The Flying Hippos. The special alien color scheme was prepared for NATO Tiger Meet 2016 in Spain, where the photo was probably taken. At that event, the helicopter received "the best camouflage award."

Hynek Walner
PRAGUE, CZECH REPUBLIC

The reader is correct.

TWITTER POWER

Byron Callan's No. 2 prediction in the Upfront column "Fasten Your Seat Belts" (*Dec. 26, 2016-Jan. 8, p. 16*) juxtaposes nicely against Lara Seligman's "Negotiator-in-Chief," about a better deal for Boeing's new Air Force One (page 24).

President-elect Trump's tweets do something long-needed; they provide a direct conduit of information to taxpayers. Our massive federal debt is at least in part due to a government unwilling to negotiate hard, demand competition and performance and an industrial complex all too willing to provide "$600 hammers" under the excuse of "costly small production runs."

Neither the press nor Congress seem to be informing taxpayers of these things in a timely manner, but a tweet does so quickly and can elicit reactions. Witness the speed in which Boeing's CEO released a public response about controlling costs following Trump's Air Force One tweet.

Todd Fredricks
AMESVILLE, OHIO

AIR FORCE ONE ALTERNATIVES

Since there is no rule that a U.S. president must have a Boeing 747, especially a two-aircraft "fleet," I suggest that we cancel the 747 contract and add four more aircraft to the KC-46 fleet. These would be wired and plumbed for tanker use, but two of them could be completed as passenger aircraft and outfitted as Air Force One aircraft.

Although there would not be as much room as in the 747 for "strap-hangers," future presidents would have ample room, and the Air Force would have four aircraft that would be identical, for the most part, to the tanker fleet—a plus for parts management, crewing and maintenance—not to mention the cost factor.

Roger D. Haneline
SAVANNAH, GEORGIA

AF 1 CONTENDER

I agree with the notion of adding competition to an Air Force One replacement, but a simple competitor to a new aircraft is readily available and is usually found in its own hangar at Joint Base Andrews in Maryland. Why not appoint a team to evaluate the longest possible service life of the 747-200?

Fatigue life, avionics modernization, and at some point new engines should all be considered. A robust spares inventory of major components could be obtained at bargain prices as 747s retire from airline use.

Shifting presidential travel to smaller aircraft for short trips could also be included in the plans to extend the service life of these aircraft. Based on our experience with much harder-used military Boeing airframes such as the KC-135 and B-52, it might be possible to achieve a service life 40-50 years longer than the current projection. Addressing our national debt will require some difficult choices. What better place to start than at the top with the president's airplane?

Michael R. Gallagher
HILLSBORO, OREGON

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awstletters@aviationweek.com
Letters may be edited for length and clarity; a verifiable address and daytime telephone number are required.

SUMO-SIZE SHARING

"Sumo Size" (*Dec. 26, 2016-Jan. 8, p. 28*) about the Japanese fifth-generation fighter proposal describes that country's efforts to develop an "FB-22-size" aircraft. Interestingly, Japan's attempt to buy F-22s years ago was denied due to a congressional ban on exporting the aircraft's technology.

The U.S. and Japan should consider co-developing the FB-22 for many reasons: First, to save money by producing an aircraft that could serve as both a long-range interceptor and strike aircraft. Second, prior design work on the FB-22 could save time, a critical factor given escalating threats from China and North Korea. Third, much of the F-35's cutting-edge technology could be incorporated into this new aircraft, saving time and money.

Given President-elect Trump's concerns over the cost of the F-35 and Air Force One programs, he may reject the U.S. Air Force B-21 bomber project altogether; the FB-22 could offer a timely and relatively cost-effective alternative to the proposed long-range strike aircraft.

The F-35 shows that Lockheed Martin can honcho a multinational, potentially profitable program. It would be interesting to watch our president-elect's "deal maker" skills in facilitating this.

Alan E. Diehl
ALBUQUERQUE, NEW MEXICO

Correction:

Many readers caught our mistake in an appreciation of John Glenn (*Dec. 26-Jan. 8, p. 138*). We wrote that his MA-6 Mercury mission, in which he orbited Earth three times and seemed to experience serious problems, had been cut short from the planned seven orbits. His spacecraft was launched with enough energy to complete seven orbits before becoming unstable. After his spacecraft separated from the launcher, controllers told Glenn he was "go for seven orbits," indicating Friendship 7 had achieved the energy expected. But in fact the mission was never intended to orbit Earth more than three times.

Who's Where

J. Lydon-Rodgers

Tony Mathis

Kenneth Onderko

Anders Carp

Victoria Foy

Gonen Usishkin

Richard Dobson

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.*

Air Berlin has named **Thomas Winkelmann** CEO. Winkelmann had been CEO of Germanwings and head of Lufthansa's hub.

GE Aviation has promoted **Jean Lydon-Rodgers** (see photos) to president/CEO of services from president/CEO of military systems and **Tony Mathis** to president/CEO of military systems.

Mitsubishi Aircraft Corp. has promoted **Yuichi Shimbo** to vice president of aircraft integration/engineering and chief engineer of flight test management, **Kenya Ishihara** to vice president of mechanical system design/MRJ 70 project office from engineering manager and **Makoto Goto** to vice president of electrical system design/engineering from vice president of system design/engineering.

Kenneth Onderko (see photo) has been named president of *Nexcelle*, the GE Aviation-Safran Nacelles joint venture for integrated propulsion systems.

Saab has promoted **Anders Carp** (see photo) to head of surveillance and to the management group. Carp had been head of traffic management.

Safran Nacelles has named **Victoria Foy** (see photo) managing director of its facility in Burnley, England. She succeeds Chris Plumb, who will retire.

AerCap Holdings has promoted **Peter Juhas** to chief financial officer from deputy CFO. Juhas had been AIG global head of strategic planning.

Marenco Swisshelicopter has named **Andreas Loewenstein** as CEO. He succeeds Martin Stucki, who has retired.

Lufthansa Group has named **Tamur Goudarzi-Pour** vice president of sales for the Americas. He had been director of network planning at Lufthansa's Munich hub.

The Aerospace Corp. has promoted **Malina Hills** to senior vice president of space systems from vice president of space program operations and named **Wayne Goodman** executive vice president. They jointly succeed Dave Gorney, who has retired.

TransDigm aerospace components group has promoted **Robert Henderson** to vice chairman from chief operating officer of airframes and **Kevin Stein** to president/COO from COO of power. As president, Stein succeeds W. Nicholas Howley, who will continue as chairman/CEO.

Gonen Usishkin (see photo) has been appointed *El Al* vice president of the commercial division. He succeeds Shali Zahavi, who will retire.

John Walker returns to *Delta Air Lines* as a senior advisor. He had been chief communications officer and then advisor in 2008-14.

Parsons Engineering has named **Carey A. Smith** president for federal business. Smith had been with Honeywell Defense and Space and before that with Lockheed Martin.

Marshall Aerospace and Defense Group has appointed **Alistair McPhee** as CEO. McPhee had been with Thales UK.

JetSuite charter company has hired **Michael Bata** as chief operating officer. Bata had been chief operations officer at Vueling and before that was with Southwest Airlines.

Milestone Aviation, a GE Capital Aviation helicopter leasing company, has appointed **Daniel Rosenthal** president/CEO. He succeeds Richard Santulli.

Vertis Aviation has promoted **Catherine Buchanan** to chief commercial officer from general manager of the company's Dubai office.

CommutAir has named **Radha Iyer** chief technology officer, hired **Jeffrey Penn** as chief inspector and promoted **Jobin Dhaliwal** to director of crew resources. Iyer had been United Airlines director of operations for automation and innovation.

Cubic Mission Solutions has hired **Jeremiah Madigan** as vice president of secure communications and **Robert M. Peabody** as vice president of systems strategy.

Vladimir Zubkov has been named secretary general of the *International Air Cargo Association*. Zubkov, who had been Volga-Dnepr vice president, succeeds Doug Brittin, who will retire.

Serco Inc., a government management services company, has hired **David Cummins** as senior vice president of transportation, overseeing fleet management, aviation and air traffic control.

The Civil Air Patrol has named **John Salvador** chief operating officer, overseeing affairs at the national headquarters at Maxwell AFB, Alabama.

Trego Dugan Aviation in North Platte, Nebraska, has named **Debra Mendonca** vice president of human resources and **Lorie O'Donnell** vice president of finance.

Airline Services Interiors has promoted **Richard Dobson** (see photo) to managing director from commercial director.

Robert Wood has been named communications director of the *International Association of Machinists and Aerospace Workers*. He succeeds Frank Larkin who is retiring.

HONORS & ELECTIONS

John Wing has received an Aircraft Maintenance Technology 2016 40 Under 40 Next Gen Award. He is a *Pemco World Air Services* program manager.

Diane M. Bryant, executive vice president of Intel, has been elected to the *United Technologies Corp.* board.

CPI Aerostructures Inc. has named **Carey E. Bond**, former Sikorsky Aircraft president, to the company's board of directors.

The *International Civil Aviation Organization* has appointed **Hajime Yoshimura** president of its Air Navigation Commission.

First Take

TEXTRON AVIATION

DEFENSE

Textron AirLand flew the first production-conforming Scorpion on Dec. 22. Changes to the light surveillance/attack jet include a Garmin G3000 integrated cockpit and 4 deg. of wing sweep.

Leonardo flew the prototype M345 jet trainer on Dec. 29. The former S.211/M311 prototype is updated with new nose, avionics, inlets and Williams FJ44-4M turbofan. Deliveries to Italy are to begin in 2018.

At least five teams will bid for the $16.3 billion U.S. Air Force T-X competition to supply 350 advanced jet trainers and ground-based training systems following release of the request for proposals on Dec. 30.

A request for proposals for the $6.9 billion competition for 17 battlefield-surveillance aircraft to replace the U.S. Air Force's E-8C Joint Surveillance Target Attack Radar System fleet was released in December.

WEIBO.COM

Flown in late December, the second prototype of China's Shenyang FC-31 stealth fighter shows significant changes to the forward fuselage, cockpit and tails as well as a revised wing planform.

Pilatus has sold 17 PC-21 turboprop trainers for the French air force, two to the UK's Qinetiq for use by the Empire Test Pilots School and an additional pair to boost Jordan's fleet to 10.

Lockheed Martin shares fell on Dec. 23 when President-elect Donald Trump again attacked F-35 costs and overruns and tweeted that he had "asked Boeing to price-out a comparable F-18 Super Hornet."

Asymmetric flap deployment is a possible cause of the Dec. 25 crash of a Russian defense ministry Tupolev Tu-154 into the Black Sea after takeoff from Sochi, en route to Syria, that killed all 92 on board.

ALEXEY FILATOV

Ordered to replace the Ukrainian Antonov An-140T planned for procurement by Russian armed forces, the Ilyushin Il-112V light transport is in final assembly at United Aircraft Corp.'s Voronezh aircraft plant.

Norway's planned purchase of five Boeing P-8 maritime patrol aircraft, submitted for parliamentary approval in November, has been cleared by the U.S. government and valued at up to $1.75 billion.

Leonardo has taken full control of Italy's Sistema Dinamica, acquiring the remaining 60% of shares in the Pisa-based manufacturer of the SD-150 Hero small unmanned helicopter.

Korea Aerospace Industries has received a $520 million contract to produce 30 KUH-1 Surion indigenous helicopters for the South Korean marine corps, in addition to the 245 planned for the army.

COMMERCIAL AVIATION

Brazil is to launch a World Trade Organization dispute against Canada claiming illegal state subsidies for Bombardier and citing $2.5 billion invested by Quebec in 2016—$1 billion in the C Series program and $1.5 billion in its rail business (page 11).

China's Comac C919 narrowbody airliner began taxi tests at Shanghai in late December, following certification of its CFM International Leap 1C engines. First fight is expected in the second quarter.

ZHANGMX969/WEIBO.COM

Sukhoi plans to complete repairs on affected Superjet 100s by late January following inspections for fatigue in horizontal-stabilizer attachment bands. Mexico's Interjet grounded 11 of 22 aircraft for repair.

The 118 passengers and seven crew were released unharmed and two hijackers surrendered after diverting an Afriqiyah Airways Airbus A320 en route from Sebha to Tripoli in Libya to Malta on Dec. 23.

An Aerosucre Colombia Boeing 727 freighter crashed after barely clearing the perimeter fence on takeoff from Puerto Carrena Airport in Colombia on Dec. 20, killing five of the six crew.

Air Transport Services Group, which operates Boeing 767 freighters for Amazon, has acquired maintenance provider Pemco World Air Services, which also modifies 737s to freighters.

First Take

GENERAL AVIATION

China's Wanfeng has purchased 60% of Canada's Diamond Aircraft Industries from its Austrian parent and acquired all rights to produce the DA40 single- and DA62 twin-engine light aircraft. The stalled D-Jet single-engine jet is part of the deal.

Cirrus Aircraft delivered the first seven-seat SF50 Vision Jet on Dec. 19. The first single-engine personal jet, powered by a Williams FJ33-5A, was handed over to an Arkansas-based real-estate developer.

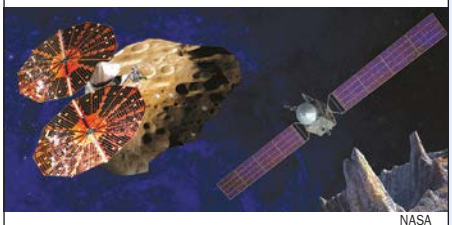
Bell Helicopter received Transport Canada certification for the Model 505 Jet Ranger X on Dec. 21 and plans to begin deliveries of the five-seat, single-turbine helicopter from Mirabel early in 2017.

A revamped Part 23 rule allowing use of industry consensus standards to speed certification of small aircraft was released by the FAA in December. Europe's revamped CS-23 will follow in the first quarter of this year.

Dassault's backlog of Falcon orders declined to 63 at the end of 2016, down from 91 a year earlier, after only 33 new orders came in and 12 for the delayed Falcon 5X were canceled.

Aerostructures supplier Triumph Group is suing Bombardier for $340 million to cover costs incurred by a redesign of the Global 7000 wing. Bombardier plans to countersue over delays to the program.

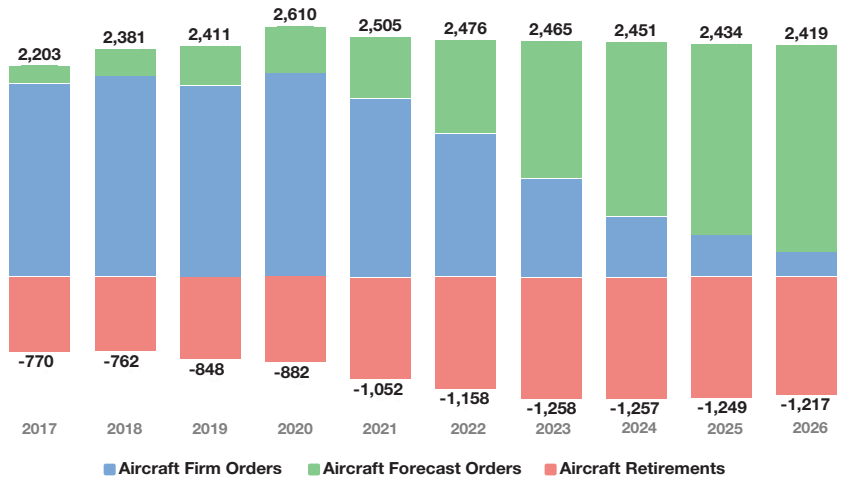
SPACE



NASA

NASA has selected two new asteroid exploration missions. Lucy, for launch in 2021, will fly by six of Jupiter's Trojan asteroids in 2027-33, and Pysche, to launch in 2023, will arrive at the main-belt metal asteroid 16 Psyche in 2030.

Aircraft Deliveries vs. Retirements



Source: 2017 Commercial Aviation Fleet & MRO Forecast, Aviation Week Network

The world commercial aircraft fleet will grow to 46,200 from 33,240 in 2017-26 on the strength of 24,300 deliveries, offset by 10,400 retirements, according to the Aviation Week Network's latest Commercial Aviation Fleet & MRO Forecast.

Digital Extra *For more information, see* **AviationWeek.com/2017forecasts**

NASA has awarded both Boeing and SpaceX four more crew flights to the International Space Station, for a total of six each to begin in 2018 once their vehicles are certified for human spaceflight.

Failure of a carbon-wrapped helium tank during loading of supercooled liquid oxygen into the second stage caused the Sept. 1 Falcon 9 launchpad explosion, says SpaceX, which hoped to return to flight Jan. 8.

47 YEARS AGO IN AVIATION WEEK

Thirteen months after the first flight of the Soviet Union's Tu-144 and 10 months after Europe's Concorde took to the skies, Aviation Week opened the 1970s with a 38-page report on the U.S. supersonic transport (SST) program. Our cover featured a mockup of the Boeing 2707-300 transport, which was "evolving into a family of five or more aircraft." But there were already warning signs: The government-backed Boeing development was counting on sales of 500 SSTs, but market forecasts varied widely, from as many as 1,200 airplanes to as few as 100. The SST program was canceled in 1971. The Concorde entered service in 1976, but only 20 were built, including six prototypes, and the aircraft was retired in 2003. The Tu-144 was in service just seven months before it was shut down after a 1978 crash.

Read the in-depth report on the U.S. SST program in the Jan. 5, 1970, edition of Aviation Week at: **archive.aviationweek.com**

By Michael Bruno

Michael Bruno is Senior Business Editor
Join the conversation at:
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michael.bruno@aviationweek.com

COMMENTARY

Come Together

Subsidy cries among OEMs are crescendoing again, but could this time bring harmony?

New flare-ups in old international trade grievances among aircraft manufacturers are raging again. If recent actions are a good indicator, they look unlikely to burn out anytime soon.

But what if this time is different? What if—just, if—this is the last cathartic round of meaningless litigation in the otherwise never-ending World Trade Organization (WTO) disputes? Hope springs eternal, but it is not entirely unfounded. Just don't hold your breath.

December was full of developments, with the U.S. formally appealing one of the Boeing-Airbus cases at the WTO: the Washington state's business and occupation aerospace tax rate for the manufacturing or sale of Boeing 777Xs.

Meanwhile, Embraer's home government started ramping up for another WTO fight against Canada's Bombardier, with Brazil's highest government institution for foreign trade policies calling for a new, formal trade dispute between Brazil and Canada.

Embraer says the dispute involves subsidies of more than $4 billion allegedly provided by Canada to Bombardier, Embraer's main competitor in the regional jet commercial aircraft sector. In 2016 alone, Embraer charges, Bombardier benefited from $2.5 billion from state sponsors.

"The Brazilian government's understanding, shared by Embraer, is that the Canadian government's subsidies to Bombardier not only enabled the company to survive, but also allowed Bombardier to offer its aircraft to customers at artificially low prices, distorting the commercial aircraft market and violating Canada's WTO obligations," Embraer says.

During a roundtable discussion with Aviation Week in December, Embraer CEO and President Paulo Cesar de Souza e Silva complained that his company is no longer competing with just Bombardier, but rather Canada. "We continue to be very unhappy; we are very worried about the situation," he said. "This is causing a huge disruption in the market, so we are no longer operating on a level playing field."

REMO CASILLI/REUTERS/NEWSCOM

Embraer CEO and President Paulo Cesar de Souza e Silva

In turn, Embraer wants a more "disruptive" response against Bombardier and Canada, Silva said. As part of the Embraer statement, Silva said "the WTO is the only means to ensure a level playing field in the market."

Of course, Canadian officials argue that everything has been legal. But they also admit what everyone knows. "There is no country in the world that doesn't heavily subsidize its aerospace sector," Canadian Prime Minister Justin Trudeau told reporters last July.

Along those lines, Silva told Aviation Week he knew Embraer's new WTO effort is unlikely to settle things for good and that the aircraft manufacturing industry worldwide must come to a universal agreement about state subsidies, like it did under the Organization for Economic Cooperation and Development's 2011 Aircraft Sector Understanding (ASU) for international aircraft financing. That deal also came after seemingly unending trade disputes.

"The WTO is not the solution," Silva acknowledged. "Depending on the case, the best-case scenario is it takes 6-8 years. As an aircraft manufacturer, what I would like . . . is an industry agreement for this kind of situation like the ASU, which is working very well. As an industry we should think about that."

Silva echoed comments made a month earlier by Airbus Group CEO Tom Enders. "I continue to think that the only way out of the ridiculous series of disputes initiated by the U.S. is to agree on a set of globally applicable rules for the support of the civil aircraft industry, which would benefit both sides of the Atlantic," Enders emailed Reuters. "The duopoly is no longer the framework of reference in the future," he stated, citing Quebec's help last year with Bombardier.

There are other impetuses for ending the Western OEM WTO war, starting with China's and Russia's high-profile programs to build rival commercial aircraft. Western analysts can debate how quickly or effectively those home-grown airplanes will displace current OEM market share, but make no mistake, that is the intent. Arguing with each other may be just want the Russians and Chinese would like Westerners to keep doing.

But if WTO fights do not settle anything, why bother? Eric Shimp, policy adviser at Alston and Bird, a Washington law firm familiar with WTO rules, noted last year that WTO cases lay the markers for later, universal agreements like the ASU (*AW&ST* July 1, 2016, p. 68). Silva concurs.

WTO fights are a means to an end, but almost everyone knows it will not be the end of state sponsorship. It is time to stop pretending otherwise and time to start determining what is acceptable, like it or not.


UBER

By Antoine Gelain

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COMMENTARY

Smaller, Slower and Closer

A new era of air transportation systems

The beginning of a new year is always a good occasion to reflect on major trends that have been taking shape in the past 12 months. One development in commercial aviation is the emergence of new air transportation concepts taking us one step closer to a "Blade Runner" type of future, where flying cars become part of a three-dimensional transportation system. Uber's Elevate concept paper, published in October, gives a glimpse of what is on the drawing board: fleets of autonomous vertical-takeoff-and-landing (VTOL) vehicles flying around megacities and cutting our daily commuting time by nearly 90% for a price that could ultimately be the same as a taxi ride.

Regardless of how and when this vision becomes reality, there is no question that such futuristic transportation concepts have the potential to take the aviation industry in a completely new direction, with some major consequences for all its stakeholders.

The most obvious one is that the race for bigger, faster and farther may finally be reversed. From the time when aviation pioneers like Charles Lindbergh were flying single-seat, single-engine, purpose-built monoplanes to the current generation of mass-produced jets that can carry several hundred passengers, the history of commercial aviation has been primarily about creating bigger and more powerful flying machines. In that race, Boeing and Airbus have come out on top, monopolizing the market for large commercial aircraft and setting the innovation agenda for the rest of the industry.

Today, however, the challenge for new air transportation systems is of a very different nature. In the context of on-demand urban air transportation, it is not about making "bigger" better but about making "smaller" better—both technologically and economically.

Technologically, the constraints for flying in an urban environment are such that only vehicles of a certain size will be able and allowed to do it. And they will need to be quiet, fast, clean, efficient and safe, all of which is more likely to be achieved with technologies such as electric propulsion, vertical lift and autonomy that are better adapted to small-scale vehicles. Even solar propulsion could be an option for some small vehicles, as Bertrand Piccard's Solar Impulse first round-the-world solar flight brilliantly demonstrated last year.

As far as autonomy is concerned, thanks to swarm intelligence and advanced precision positioning technologies, it may actually turn out to be easier and safer to operate and monitor fleets of small, self-driving air vehicles than large transcontinental airliners flying over oceans.

Economically, the only way to make such new means of transportation viable—even in a ride-sharing or taxi format—is to bring the acquisition price of the vehicle close to that of a typical car. This will require the vehicles to be small enough to fully leverage the potential of 3-D-printing technology and to make thousands—if not tens of thousands—of them every year to generate sufficient economies of scale.

Overall, this points to a future of aviation in which most innovations will be driven by new applications and new performance dimensions (such as noise, emissions and agility), where the economics of manufacturing VTOL vehicles will become more akin to automobiles than aircraft, and flying will become much more user-centered and part of a fully integrated and largely individualized mobility service.

The aviation ecosystem as we know it is therefore likely to change dramatically in the next few decades. As people start rethinking transportation in three dimensions and flying becomes an integral part of individual mobility scenarios, traditional air travel—on large airplanes, to and from distant airports, on fixed schedules and limited routes—will increasingly look old-fashioned and out of sync with the modern urban lifestyle. Airlines may rebrand themselves as luxury cruise operators, Boeing and Airbus may keep battling it out, but they will lose their status of industry trailblazers. The aviation world as a whole will become much more diverse and its boundaries much more permeable.

Ultimately, thanks to technology and human creativity, aviation in the 21st century may even bring us back to the original vision that drove many of its pioneers but was widely lost in the quest for largeness and productivity: making air travel suitable for small-scale applications, cheap enough so that it is accessible to virtually everyone and compatible with the human aspiration for freedom, adventure and beauty. As Lindbergh said: "It was that quality that led me into aviation in the first place, it was a love of the air and sky and flying, the lure of adventure, the appreciation of beauty."

By William Garvey

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COMMENTARY

Shared Economy

An old idea, albeit made more sure, again

A long time ago, Berl Brechner, a fellow aviation scribbler, and I pooled our meager funds to buy an airplane. It was a leap of faith since at that point we didn't know each other well, and our respective piloting abilities along with our financial track records were presumed. And who could say into what kind of fiscal black hole N8364M—a used VFR Cessna 150 Aerobat—might lead us.

Thankfully, when the joint ownership ended years later because of new jobs for us both, our partnership's dissolution was most amicable and orderly and our reliable 64Mike went to new owners. Our parting, however, was apparently something of an exception. Too many airplane partnerships, it seems, begin with great expectations and end with grumblings about that other lousy so-and-so.

PARTNERS IN AVIATION

Mark Molloy (left) and Tom Bertels, PIA co-founders, offer a shared aircraft opportunity.

The causes behind such a stark change in attitude can be many: tardy or missed payments, rough aircraft handling, scheduling conflicts, disagreements over proper maintenance and equipage, homeport choice, slovenliness, and a blocked effort to sell one's share, among others.

The appeal of co-ownership for those who plan to use an aircraft less than 150-200 hr. annually is obvious and potent, says Mark Molloy, who recently retired from a 34-year career as a King Air salesman. After all, he notes, such buyers get to own an airplane for 50 cents on the dollar. Thus, shared aircraft ownership constitutes "the strongest financial model," he says, but because of the aforementioned conflicts makes for "the worst practical model."

As a result, when selling King Airs to low-time users he often tried to dissuade the customer from creating an ad hoc co-ownership agreement. Rather, he'd steer the buyer toward a FAR 135 operator who could at least offset some of the expense of sole ownership via charter revenue. But even that arrangement often led to disappointment, since the income realized could be modest while chartering added wear and tear and reduced aircraft availability.

Molloy regarded fractional ownership as a better option for low-time users because it gave the shareholder independence from fellow owners and ready access to aircraft. However, it was the most expensive source of lift. The best solution, he thought, was one that delivered the 50% reduction in acquisition and fixed costs of co-ownership, yet provided each owner autonomy.

And thus was born Partners in Aviation (PIA). Teaming with aviation adman/marketer Tom Bertels, Molloy sought to create a system that would address in advance all the flaws of co-ownership. After a year spent consulting with veteran aviation legal, tax, maintenance and aircraft management experts, along with several manufacturers, the service launch is underway and initial reaction looks promising.

Here is how it works. A customer approaches PIA, interested in operating an aircraft, but because of anticipated low usage is unable to justify sole ownership. PIA helps identify the appropriate new or almost-new turbine aircraft for the mission, then finds a potential co-owner in the same locale with a similar operating need as well as the financial wherewithal to easily handle the acquisition and operational obligations involved. There can be no more than two co-owners under PIA's plan.

At that point, the new co-owners sign an agreement that places all operational control under a management company, provides a set usage schedule for each, and calls for divesting the airplane in three years using a valuation formula detailed in the agreement.

Why three years? Because anything longer "starts to feel like the 'Hotel California,'" where you can never leave, says Bertels. If the co-owners wish to extend the agreement, they can do so; otherwise, the aircraft is sold, and the partnership ends. PIA, which charges both co-owners a fee for its services, can assist in the sale, if desired.

The co-owners pay monthly fees to the management company, plus a per-hour rate for aircraft usage. PIA has worked with Jet Support Services Inc. and others to establish fixed maintenance costs. Well briefed on the plan, Jet Aviation has expressed an interest in providing management services for co-owned aircraft as well. Since dual owners are autonomous in tax and title, each can handle depreciation to best serve their respective interest. The appeal of the arrangement is "it takes all the unknowns out," says Bertels.

Should one of the owners default, the agreement gives the other the right to acquire that equity under advantageous terms, or PIA could, if asked, remarket it. On that point, Bertels says, "We look for guys who can afford it alone."

While PIA's current focus is on professionally crewed and managed aircraft, the company plans to launch "Coupled Approach," a similar, but less expensive service for owner-flown turbine aircraft in 2017.

Berl and I now live 1,500 mi. apart, so we're not PIA candidates, but we do look back fondly on the time we shared and cared for 64Mike, which carried us into aviation adventures to last a lifetime.

By Jens Flottau

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COMMENTARY

Course Correction

Will the Transportation Department under Trump follow the Obama administration's lead?

Many players in opposing camps in the industry have been dismayed by the blatant inactivity of the Transportation Department under President Barack Obama. It took the department essentially three years to issue a foreign air carrier permit for Norwegian Air International (NAI), a procedure that should have been routine. And the administration took almost as long to define a position on the alleged subsidies for Gulf carriers and potential policy responses.

IRAN AIR

But during the last few weeks, the department is making some noteworthy decisions. First of all, NAI can finally become a reality. It is hard to imagine how the Trump administration could overturn that call, and if it remains in place, it is an important milestone for establishing the transatlantic low-cost long-haul model. Why? Because much like low-cost short-haul, the model needs more than one giant hub through which most traffic is fed. It requires multiple points of departure big enough to sustain long-haul services without the same amount of feed that legacy carriers enjoy for their widebody operations. In that sense, the model is more complex and broader, but it has the potential to tap into more markets, particularly those without daily services.

In addition to the NAI decision, the department has set tight conditions for a possible approval of the planned deepening of the relationship between Delta Air Lines and Aeromexico, while blocking a joint venture between American Airlines and Qantas. A decision on a similar arrangement between American and LATAM Airlines is still pending.

It is clear that the Obama administration is now taking a less industry-friendly approach to airline consolidation than it and its predecessors have in many years. Even so, the U.S. airline industry has been allowed to merge into essentially four big players via four mergers. At the same time, three joint ventures with their transatlantic alliance partners have been created that control more than 80% of the transatlantic market. The remaining non-joint venture service has been high-profile—just think of Norwegian or Emirates' Milan-New York service—but it is not significant in the grand scheme of things yet.

A closer look at the moves that may still be justified beyond the recent wave of consolidation is, of course, entirely sensible. Airlines have greatly benefited from the relatively friendly regulatory environment of late, but governments are not created to make airlines happy, and carriers should always keep the big picture in sight. There are, however, still regions where further consolidation is appropriate and justified—Eastern Europe and Asia are two examples.

Germany is just witnessing the collapse of Air Berlin and its likely full integration in some form into the Lufthansa Group. Approval, although likely because no government wants to be held responsible for the loss of thousands of jobs in an election year, is already a more doubtful move because it would leave only one major airline in the country.

The big question in the U.S. is whether the rediscovered consumer advocacy role of the Transportation Department will continue under the Trump administration. The consensus is that it probably will, but not for very long. The president-elect's cabinet nominees, not surprisingly, suggest that he supports business-friendly policies across the board, and why should airlines be an exception?

For ideological reasons, the case may be different for Boeing and Airbus, both of which are in the process of finalizing major aircraft sales to Iran. Breaking up the nuclear deal, which allows deliveries of new Western aircraft to Iranian airlines, would be contentious and complicated, but not impossible. Even if the deal stands, the orders from Iran are not the temporary rescue for their mammoth 747-8 and A380 models that Boeing and Airbus initially hoped for. Those aircraft initially had been part of Iran Air's grand resurrection plans when the preliminary commitments were made public almost a year ago.

The decision not to order the huge airliners makes complete sense. The revival of the airline—long hampered by Western sanctions—will be complicated and difficult enough. The 747-8 and A380 work for very few of the most established airlines in Europe and Asia, so Iran Air has every reason to avoid making more daunting the task of becoming a large international airline again. There is significant long-haul demand into and out of Iran, but that can be most efficiently served using twin widebodies.

For Airbus, the loss of Iran Air's interest in the A380 could turn out to be very painful, particularly after Emirates' decision to defer deliveries of a total of 12 aircraft by one year forced the manufacturer to cut production rates of the aircraft type again.

By Graham Warwick

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COMMENTARY

Reinventing Genav

New U.S. and European rules promise to advance small aircraft more quickly and cheaply

It is fitting that Cirrus Aircraft delivered its first SF50 Vision Jet in December, just days after the FAA issued its final rule overhauling airworthiness standards for small aircraft. The first FAA-approved single-engine personal jet (see photo) is symbolic of the need to revamp certification processes so general aviation (GA) aircraft can be developed, and upgraded, more quickly and cheaply.

CIRRUS AIRCRAFT

The Vision Jet took 10 years to certificate and languished for several of those years until Cirrus in 2012 received sufficient investment from its new Chinese owner to complete development. The FAA's new Part 23 rule, and upcoming revamp of Europe's CS-23, is intended to reduce the time and cost to certificate aircraft under 19,000 lb. by replacing outdated and prescriptive airworthiness rules with industry consensus standards that can evolve with technology.

As proof that technology is available to improve GA, the Vision Jet is not alone. Tamarack Aerospace has received U.S. certification for its performance-improving Active Winglet retrofit on Cessna's CitationJet family. Also this month, Garmin's next-generation G1000NXi integrated flight deck was introduced on all Cessna and Beechcraft piston singles and twins and by Cirrus on the latest G6 version of its SR20/22. There is even a possibility the Vision Jet's one-time rival, the Diamond D-Jet, could be revived. Following the December acquisition of 60% of Diamond Canada by Chinese conglomerate Wanfeng, the stalled D-Jet "is subject to ongoing review," the company says.

All are examples of advances the Part 23 revamp is intended to make easier. With the U.S. Congress gaining praise for putting pressure on the FAA to act, the new rule has been greeted enthusiastically by a GA community that has seen many projects founder on the cost and complexity of certification.

But the real excitement goes beyond known products and projects as the GA community looks to future technologies that could revitalize—and potentially revolutionize—an industry sector that has struggled in recent years. From its recent peak of almost 2,800 aircraft in 2006, shipments of piston aircraft fell below 900 in 2011 and will barely have exceeded 1,000 in 2016. The industry hopes advances such as electric propulsion and safety improvements will boost demand.

To better keep pace with technology, certification procedures had to change, and the new Part 23 allows manufacturers to demonstrate compliance with airworthiness requirements using consensus standards developed by industry. The goal is for standards to be agreed upon far more quickly than regulations can be changed, allowing the industry to keep up with technology advances.

The first volume of standards is in place and is expected to be referenced as an acceptable means of compliance before the end of the eight-month rule implementation period in August. The European Aviation Safety Agency, meanwhile, is scheduled to complete the revamp of CS-23 in the first quarter, resulting in harmonized rules referencing identical standards.

Work on new technologies is already underway within standards developer ASTM International. "We are working to finalize a standard for electric propulsion (first-quarter 2017), new methods of increasing crashworthiness, preventing loss of control, analyzing aeroelasticity, etc.," says Greg Bowles, vice president for global innovation and policy at the General Aviation Manufacturers Association. Work is also underway on better paths for designing cockpit retrofits.

"As the manufacturers and aviation authorities gain better understanding, standards can be put in place in quick order," Bowles says. "As opposed to the introduction of turbine power in Part 23—the rules were updated about 40 years later—we anticipate having standardized means of compliance in place within about a year once technologies are ready."

Electric propulsion is one area where there is industry pressure for certification standards, with Airbus and others planning to produce GA aircraft with battery or hybrid power. Another beneficiary could be electric vertical-takeoff-and-landing (VTOL) vehicles, with Joby Aviation, Zee.Aero and even Airbus already developing aircraft for personal transportation and air-taxi operations.

While VTOL aircraft fall under Part 21 rules rather than Part 23, "the design is similar, and the FAA has indicated it will utilize much of the new Part 23 material for these vehicles," Bowles says. This holds out hope that startups driving development of these vehicles can avoid the pitfalls of past GA projects.

By Frank Morring, Jr.

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COMMENTARY

Bow Wave

We could see the next private human spaceflight this year

BLUE ORIGIN

Launching missions into space has never been the same as catching a flight at the airport. It takes time—usually a lot of it—to prepare a spaceflight mission, and as 2017 rolls out to the launchpad, some missions in the works for years will finally get off the ground. While the incoming administration will shape space exploration in the years ahead, the new year will see the realization of long-standing projects worldwide, regardless of what happens in the White House.

For my money, the spot to watch for significant news is Van Horn, Texas, a location so remote that state businesses bank their money there because it takes an extra day for checks to clear. Billionaire Jeff Bezos is about to put it on the international map, though, with a first flight of his suborbital New Shepard reusable vehicle carrying "test passengers" to space.

It will not be the first private human spaceflight—Scaled Composites won the Ansari X-Prize by doing that in 2004—but Bezos's West Texas outpost could become the point of departure for routine space-tourist flights in 2018. The Amazon founder has been extremely conservative in public predictions for his Blue Origin endeavor, but expects to fly with humans this year (*AW&ST* March 14-27, 2016, p. 28).

Virgin Galactic is also in the running for suborbital human missions with its SpaceShipTwo, based on the Scaled Composites design. But after the fatal 2014 atmospheric flight test of the original, it probably will not be ready to surpass the 100-km (330,000-ft.) Karman line with its upgraded vehicle this year, given the complex flight-test program company managers envision.

Private orbital spaceflight will have to wait until late 2018. Boeing and SpaceX both had planned to send test crews to the International Space Station for NASA this year, but technical reality intervened, and they have slipped their target dates. SpaceX is struggling to overcome the Sept. 1 on-pad explosion of a Falcon 9 second stage to the satisfaction of the FAA, which licenses commercial space launches, and January will be a crucial month for Elon Musk's company.

SpaceX has at least six launches on its manifest this month, but it remains to be seen if any of them will get off the ground. There is much riding on this return to flight. The company already has lost an Inmarsat mission to Arianespace, and the mishap is also complicating its commercial-crew certification by NASA.

Assuming the cause of the blast is fixed soon, 2017 also should see first flight of the SpaceX Falcon Heavy—three Falcon 9 core stages bolted side by side to generate 5.1 million lb. of thrust at liftoff with 27 Merlin engines firing at once. A demonstration mission is scheduled in the second quarter, and a launch carrying the U.S. Air Force's Space Test Program-2 payload is scheduled for the third quarter.

Another heavy-lift launch vehicle, NASA's Space Launch System (SLS), is scheduled to arrive at Stennis Space Center in Mississippi at around the same time, to begin preparations for passing a major hurdle on its way to lunar orbit in 2018 on NASA's first "Exploration Mission" with its big new rocket and the Orion crew capsule.

Workers will hoist the Saturn V-class SLS core stage into the B-2 test stand that once hot-fired the Apollo Moon rocket and hook it up for a full-duration test with all four refurbished RS-25 space shuttle main engines firing at once (*AW&ST* Sept. 12-25, 2016, p. 36). The "green-run" static test of the stage is set for year-end, although NASA concedes it could slip to 2018.

NASA has the largest budget for civil spaceflight, but it has plenty of company above the atmosphere. India's long-awaited upgrade of its Geostationary Space Launch Vehicle (GSLV Mk. 3) is scheduled for its first orbital mission early this year from the Indian Space Research Organization.

Designed to launch payloads weighing as much as 4 metric tons (8,800 lb.) at liftoff, the launcher has been in development for 15 years, delayed by difficulty developing indigenous cryogenic rocket technology for the upper stage, to eliminate the need for Russian engines. A successful orbital mission will advance India's domestic space-launch capacity significantly.

China, too, is awaiting an important first-flight launch for its ambitious space program. In April, a Long March 7 is scheduled to launch the Tianzhou 1 cargo carrier from Hainan Island to the Tiangong 2 mini-space station. The unmanned vehicle will add another piece to the infrastructure China's human-spaceflight organization will need to operate its planned space station, now set for completion in 2022, with the ability to deliver pressurized and unpressurized supplies and equipment and to refuel the orbiting outpost.

LOCKHEED MARTIN

COMMENTARY

Huge Inheritance

At the Pentagon, Obama leaves behind new contracts worth billions

On his way out the door, President Barack Obama set in motion a flurry of multibillion-dollar weapons systems.

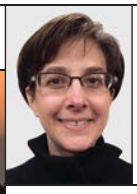
The Air Force issued bid requests for military pilot training aircraft, otherwise known as the T-X, and an E-8C Joint Surveillance Target Attack Radar System (J-Stars) replacement effort—contracts worth more than $23 billion. The Pentagon pushed forward its massive effort to modernize its nuclear arsenal, as the Defense Department's acquisition chief allowed its $125 billion Ohio-class submarine replacement program to move into an engineering design and development phase. And that decision follows solicitations issued in July for a next-generation nuclear ICBM and a long-range, nuclear-capable cruise missile.

When President-elect Donald Trump takes office on Jan. 20, he will inherit all of those programs along with ongoing priorities for building F-35 Joint Strike Fighters and KC-46A tankers, developing a new B-21 bomber and negotiating Air Force One development and production contracts. Plus, he will have to manage this batch of new programs—and their inherent cost creep and growing pains.

It will fall to Trump to select the winner in the Air Force's two recent competitions. Last year's B-21 stealth bomber competition between just two contractors, a Boeing/Lockheed Martin team and Northrop Grumman, generated a protest that delayed work on the program. But the T-X's $16.3 billion prize is more complicated. Five or six industry teams are expressing interest; with partnership agreements, the competition could involve more than a dozen defense companies worldwide. To stay on track, the winning aircraft must be ready for service by late fiscal 2024.

The Air Force's other major competition of late is for a new J-Stars tank hunter. It is worth $6.9 billion for 17 platforms. The aircraft will replace Northrop Grumman's E-8C, which is busy these days using side-looking phased-array antennas and battle management stations to track vehicles of the so-called Islamic State group in Syria and Iraq. As a special-use aircraft, J-Stars is the kind of program that generates little attention on the national stage but is a key move for the companies involved—Northrop Grumman, Lockheed Martin, Boeing and possibly Sierra Nevada Corp.—because it will position the winner to capture two future opportunities. The Air Force is looking to replace its E-3A Sentry airborne early warning and control aircraft (AWACS) and its RC-135 Rivet Joint electronic-surveillance aircraft. Early in 2016, the service's Big Safari special program office chose Gulfstream's G550 conformal AWACS platform to carry electronic warfare equipment currently on the EC-130H Compass Call aircraft.

Along with all that contracting work, Obama will leave behind massive military readiness problems that culminated on Jan. 4, with a symbol that can be milked for many maintenance dollars in 2017 and beyond: A B-52 bomber on a training flight in North Dakota dropped one of its eight Pratt & Whitney TF33 turbofans along the prairie. That will be Trump's problem to clean up. Welcome to Washington, Mr. President.



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Lockheed Martin and Korea Aerospace Industries are offering the T-50A for the Air Force's T-X next-generation trainer competition.

ORDER UP

First flights of NASA's two commercial crew spacecraft have slipped, but the agency has opted to order the full set of missions covered under the contracts worth a total of $6.8 billion. With the addition of four missions apiece, Boeing and SpaceX are now contractually bound to conduct six crew flights to the International Space Station (ISS) each, once NASA certifies their vehicles for human spaceflight.

"Awarding these missions now will provide greater stability for the future space station crew rotation schedule, as well as reduce schedule and financial uncertainty for our providers," says Phil McAlister, NASA's commercial spaceflight chief. Boeing is set to fly to the ISS with an unmanned CST-100 Starliner on a required test flight in June 2018 and send a flight-test crew in August 2018. SpaceX has pushed its unmanned Crew Dragon flight back to November of this year and its crewed flight test to May 2018. The contracted operational flights with four astronauts per flight will begin after the satisfactory conclusion of the test missions. Meanwhile, SpaceX says it has identified fixes for a helium-tank problem that triggered the on-pad explosion of a Falcon 9 last year, and is preparing to use the launcher for a resumption of commercial satellite missions. NASA has scheduled a company review later this month before it authorizes cargo flights to the ISS on the Falcon 9 to resume. NASA managers have scheduled Feb. 8 as a launch date for the next cargo mission, with berthing Feb. 11, according to Kenny Todd, the ISS operations integration manager.

Choke Points

The Joint Strike Fighter: progress and problems

Lara Seligman Washington

An Israeli F-35 "Adir," one the aircraft released for international deployment, is refueled en route to Israel in December.

STAFF SGT. STEPHENIE WADE/U.S. AIR FORCE

Lockheed Martin's F-35 achieved its first international deployment and the U.S. Air Force declared its first squadron ready for war in 2016, but the Joint Strike Fighter (JSF) also suffered key setbacks last year.

The world's most expensive fighter program continues to grapple with technological challenges. The latest version of the JSF's internal logistics system is delayed by several months, and operational test pilots are still seeing stability issues with the warfighting software. The Joint Program Office (JPO) has righted a quality issue with the avionics cooling lines that temporarily grounded 15 operational aircraft, but Lockheed is now racing to fix the 42 in-production aircraft that were affected. Further, the services are dealing with fallout from two aircraft fires this year and recent issues identified in testing.

At the same time, tensions are high between Lockheed and the Pentagon. After failing to come to an agreement on the long-awaited ninth batch of aircraft, the government in a rare move unilaterally issued a contract valued at $6.1 billion for 57 jets. The two parties are still working on a handshake agreement for Lot 10, which they had hoped to reach this fall. Meanwhile, although many of the international partners will move forward with a three-year bulk purchase of the aircraft starting in 2018, the U.S. military will not.

Designing the world's most advanced fighter does not come cheap. The JPO is racing to finish the F-35's development phase—already at $14 billion since the 2011 program restructuring—but the Pentagon is preparing for a delay of up to seven months past the planned completion date and projecting additional cost growth of $530 million. And the $14 billion is only a fraction of the full bill: A July 2016 report from the Congressional Research Service pegged the research and development cost at $59.2 billion in fiscal 2012 dollars since the program's inception.

Here we look at the F-35's remaining challenges.

Stalled Contract Negotiations

After 14 months of negotiating low-rate initial-production (LRIP) Lots 9 and 10, the government unilaterally issued Lockheed a contract for the ninth batch of F-35s. This exceptional move is rarely seen in Pentagon contracting actions but may set a new precedent.

The government could move forward with a similar unilateral action on the anticipated Lot 10 contract, JPO Chief Lt. Gen. Christopher Bogdan noted at a media briefing on Dec. 19.

"Do I want that to happen? Absolutely not," Bogdan said. "We want to negotiate in good faith and come to a bilateral agreement with Lockheed and we are going to try and do so." The JPO and Lockheed are set to begin negotiations again on Lot 10 this month.

The good news is the Lot 9 contract represents an overall drop in the average unit price, Bogdan said. Including the engine and Lockheed's fee, an Air Force F-35A costs $102.1 million, a 5.5% drop from Lot 8; a U.S. Marine Corps F-35B is down to $131.6 million, a 1.8% reduction; while a U.S. Navy F-35 is up to $132.2 million, a 2.5% increase, due to a decrease in Navy procurement quantities (see graph).

No Block Buy for U.S. Services

Per expectations, most international F-35 partners will move forward with a three-year bulk purchase of aircraft in Lots 12, 13 and 14 beginning in 2018, Bogdan said. As recently as September, he expressed confidence that the U.S. services would join in the block buy in its second year. However, Bogdan said Dec. 19 that the JPO made a "strategic communication mistake" in characterizing the services' plan as a block buy, explaining that the U.S. will instead contribute money to buy long-lead parts in bulk during the three years.

The services have already budgeted for the additional funding, called an "economic order quantity," in their fiscal 2018 budget blueprints but must ask Congress to authorize the transactions each year.

The block buy will cover 451 aircraft and save about $2 billion altogether, Bogdan said.

ALIS Delays

Lockheed had hoped to deliver the latest version of the F-35's critical logistics system, the Autonomic Logistics Information System (ALIS), by late November. But it missed that deadline and is

now aiming for February or March due to ongoing challenges with integrating the Pratt & Whitney F135 engine into the system, Bogdan said.

An internal diagnostic system that tracks each part of each aircraft worldwide, ALIS is crucial to efficiently maintaining and managing the fleet. The most updated version, ALIS 2.0.2, is planned to automatically include maintenance data from each aircraft's engine. This will ease a burden on maintainers, who currently need to have that data transferred manually from Pratt specialists, who first pull that information off the aircraft.

However, this capability will not be delivered to the warfighter for a few more months because of software difficulties in migrating Lockheed and Pratt data at the supply chain level, Bogdan explained.

The F-35 can still fly without the latest version of ALIS—even into combat. ALIS is a ground-based system that provides sustainment and support but not combat capabilities. Using an older version of the logistics system just means that maintainers have to take that extra step to track maintenance and manage daily squadron operations when it comes to engine data, Lockheed says. It also means a squadron would likely need to bring Pratt's current maintenance infrastructure in addition to the ALIS system on any deployment.

Ongoing Software Challenges

The JPO and Lockheed spent months in 2016 resolving a bug with the F-35's interim software load, Block 3i, that caused the aircraft's system to stall out mid-flight and have to be rebooted. Now the test team is seeing the same problem with the final warfighting software, Block 3F, which will enable the full-up aircraft to deploy critical weapons.

Although operational aircraft outfitted with the fixed 3i software are seeing shutdown events only every 15-20 hr., test aircraft are experiencing the problem after less than 10 hr., Bogdan said.

These glitches do not cause the aircraft to fall out of the sky, Bogdan stressed, as most of the systems on the F-35 are "triple redundant." Instead, the pilot must recycle the individual systems until they begin working again.

This kind of problem happens "all the time" with any software-intensive aircraft, Bogdan emphasized.

"F-16s, F-22s, F-18s, at some point in time when flying have computer glitches and malfunctions that require resettings, it's just a matter of how often that happens," Bogdan said. He says he is not worried about the problems with the 3F software, because the program office and industry successfully fixed similar issues with 2B and 3i.

Weapons Integration Challenges

Weapons integration, including external weapons such as the short-range air-to-air AIM-9X Sidewinder missile, is central to the final Block 3F software load. But integrating the AIM-9X has been challenging; recent testing revealed "load exceedances," or excess stress, on the F-35C variant's wing structure during landings or certain maneuvers.

This is a serious issue, Bogdan acknowledged, but it is being resolved. The JPO has engineered and ground-tested a fix, which involves beefing up the structure on the inside portion of the wing, and will flight test the solution in January. Retrofitting the fix onto the aircraft is "simple," Bogdan said, because the outer wing of the C variant comes off "like a piece of Lego." This makes it relatively easy for maintainers to remove the faulty portion of the wing and install a new part.

Putting Out Fires

The danger with beginning to buy and use an aircraft still being developed—so-called concurrency—is that unexpected problems can crop up during operations. The JPO is still dealing with fallout from two operational aircraft fires in 2016, as well as an isolated quality escape issue with the JSF's avionics cooling lines that grounded 15 F-35As in the fall.

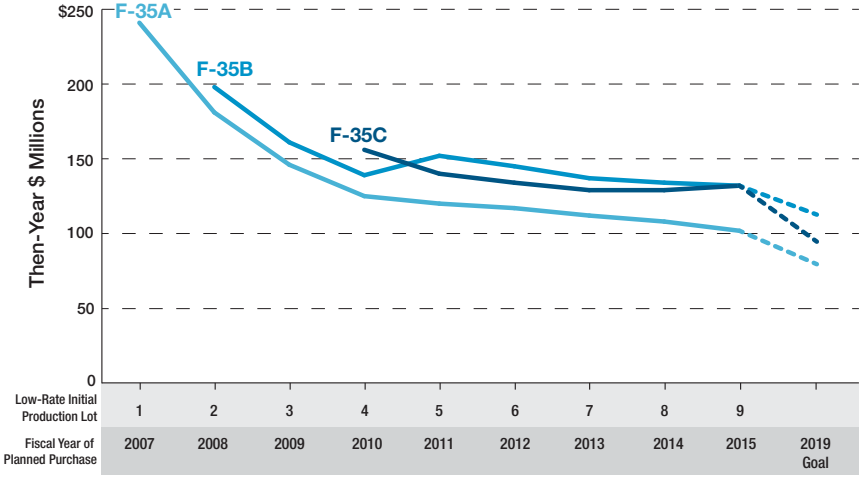
The most recent mishap occurred Oct. 27 when a fire broke out on a Marine Corps F-35B during a training flight at Marine Corps AS Beaufort in South Carolina. The root cause was a loose bracket designed to hold the electrical wires in the bay. As a result of that loose bracket, the electrical wires began to chafe and set off the spark that caused the fire. The incident was reportedly a Class A mishap, which involves damage of more than $2 million.

The JPO is retrofitting the fleet with a new, redesigned bracket, Bogdan said. Because not all B-model aircraft have been modified with the fix, pilots are flying with increased levels of risk, he acknowledged.

Just a month earlier, an F-35A also caught fire as it was preparing for a training mission at Mountain Home AFB, Idaho. The fire was quickly extinguished and no serious injuries occurred. The service is still investigating the root cause of the incident, but initial assessments point to a tailpipe fire due to strong tailwinds as the engine was starting.

Meanwhile, all 15 F-35As that were grounded last September due to loose insulation discovered in the wing fuel tanks are flying again. Lockheed is still fixing the 42 in-production aircraft that were affected by the problem though, which has slowed down the production line. The company had planned to deliver 53 aircraft this year but will deliver just 45 as a result of this delay.

F-35 Unit Cost



Note: Costs include engine and fee for Lots 1-9 without Engineering Change Order/concurrency.

Source: F-35 Joint Program Office

DEFENSE

Buffalo Successor

Twelve years on, Canada chooses its next search-and-rescue platform

Airbus has been touting the C295's proven performance in search-and-recovery and maritime patrol missions.

AIRBUS

James Drew Washington

Airbus has bested rivals Leonardo and Embraer to win Canada's Fixed-Wing Search-and-Rescue (FWSAR) competition, landing a C$2.4 billion ($1.82 billion) deal to provide 16 C295W aircraft and five years of in-service support. The decision announced in Trenton, Ontario, on Dec. 8 comes 12 years after the government originally called for a modern SAR platform to replace six 40-year-old de Havilland Canada DHC-5 Buffalos and 12 early-model Lockheed C-130 Hercules currently performing the mission over Canada's cold, vast and hazardous wilderness.

Judy Foote, minister of public services and procurement, says that under the terms of the deal, C295Ws will begin arriving in 2019, with final delivery by 2022. A simulator-equipped training center will be opened in Comox, British Columbia. The aircraft are to be stationed at the same main operating bases in Comox; Greenwood, Nova Scotia; Trenton; and Winnipeg, Manitoba. Foote says the initial contract provides for five years of in-service maintenance and support, but includes an option for 15 years of additional service that would raise the total value of the package to $4.7 billion.

Canada first began looking for a Buffalo and Hercules successor in 2004, but the program was set back repeatedly in favor of other priorities and due to concerns about the Royal Canadian Air Force's (RCAF) perceived bias toward the Leonardo C-27J Spartan.

The Liberal Party government came to power in November 2015 pledging to finally right the troubled acquisition. In March 2016, it received proposals from Airbus, Leonardo and Embraer in response to a request for proposals, offering SAR variants of their C295W, C-27J and KC-390, respectively. The competition came down to the C295W and C-27J, since the KC-390 is still in development for the Brazilian air force and Lockheed Martin decided not to compete with the C-130J Super Hercules.

Team Spartan, a joint venture between Leonardo and General Dynamics Mission Systems-Canada had been lobbying for the program since the start. The team says it will wait for a postcompetition debriefing by the government before deciding its next move.

Embraer says its turbofan-powered KC-390 is in line with all of Canada's requirements. The company said on Dec. 8 that it remains "convinced" that its platform was the right choice for FWSAR: "The flight-test campaign is progressing consistently toward certification in 2017 and we remain ready to serve Canada, as the KC-390 has all the capabilities to meet the current and future needs of the Canadian government."

The decision followed government inspections of the competing aircraft, two industry days and an "independent third-party review to ensure fairness," Foote says. It was the government's second major announcement in as many weeks, having also decided to procure Boeing F/A-18 Super Hornets as gap-fillers until a next-generation aircraft can be chosen to replace Canada's outdated CF-18 Hornets.

The winning Airbus C295W team includes PW127G engine-maker Pratt & Whitney Canada and Montreal-headquartered training provider CAE. L-3 Wescam of Burlington, Ontario, provides electro-optical sensors, while in-service support comes via AirPro, a joint venture between Airbus and PAL Aerospace of St. John's, Newfoundland. Airbus says 20% of the aircraft is already made in Canada, and it has committed to conducting business activities in-country equal to the value of the contract.

Canadian National Defense Minister Harjit Sajjan says the C295W meets all specifications and requirements of the RCAF, despite being the smaller of the two turboprops in the race, and its new sensors will make it far easier to locate those in need of help. "It is a game-changer for search-and-rescue in Canada," he says.

Sajjan says the aircraft's mission management system can track up to 200 search objects simultaneously, and the communications suite can share information in real time with other aircraft, ships, ground search crews and joint rescue coordination centers "whether it is in mountainous terrain, the middle of the Atlantic or over the Arctic in day, night and all weather conditions." The in-service support contract covers all spare parts and engineering services, and the Comox training hub is designed to keep all aircrew and aircraft technicians proficient.

Airbus Military Aircraft head Fernando Alonso says the C295W is a "simple and robust airplane" that has proven itself in SAR and maritime patrol missions around the globe. The aircraft's stout sibling, the CN235, is already in service with the U.S. Coast Guard as the HC-144 Ocean Sentry.

RCAF commander Lt. Gen. Michael Hood says the C295W will "change the paradigm" for SAR crews. "It's going to be a lot less about search and more about rescue," he says.

The aircraft has not been designated yet. A disposal plan for the Buffalos and Hercules will be crafted as the C295Ws near delivery. Once this contract is finalized, 185 C295s will have been ordered by 25 countries, Airbus says. The type joins five Airbus A310-300-based CC-150 Polaris aircraft already being used by Canada for aerial refueling and VIP transport.

Safe Bet

Airbus hopes Sea Lion will restore Berlin's faith in helicopter buys

Tony Osborne **Donauworth, Germany**

The inaugural flight of the German navy's first NH90 Sea Lion could herald a turning point in the nation's long-troubled helicopter modernization effort.

When the first helicopter arrives in 2019, it will be the first new front-line rotorcraft to be delivered to the country's fleet air arm in almost four decades. Airbus is hoping the €750 million ($798 million) project to deliver 18 helicopters will help heal wounds with the German defense ministry (Bundeswehr) after concerns about poor reliability with the army's troop transport NH90s and Tiger attack helicopters.

But both sides are playing it safe. Airbus has slightly more than two years to test and deliver an aircraft to the navy that makes extensive use of proven technology—and the authorities have given the program headroom to deliver the capabilities the navy urgently needs.

The Sea Lion will replace the Westland Sea King in the search-and-rescue (SAR), maritime reconnaissance and transport missions primarily operating from land, though they also will be capable of working from Germany's fleet replenishment ships. SAR operations with the Sea Lion are not scheduled to begin until 2022, and shipboard operations a year later.

Germany's Sea Lion is based on the NATO Frigate Helicopter derivative used by France, Italy and the Netherlands.

The Sea King urgently needs replacement. As few as 3-5 are commonly available for operations from a fleet of 21, although German authorities calculate availability based on those aircraft that are not in for overhaul or repair with industry.

"We need to keep to a tight schedule if we are to replace the Sea King on time," says Ralph Herzog, aviation director for the government's defense procurement office. "By using an existing NH90 model as the basis for the Sea Lion," he says, "and adding the required additional functionalities to it, we have been able to significantly reduce the delivery process."

The 18 Sea Lions will be built off the NATO Frigate Helicopter version of the NH90, a model also in service with five navies; however, Germany is not purchasing the dipping sonar or heavy weapon-carrying capabilities.

Germany's purchase emerged out of a 2013 memorandum of understanding with Eurocopter, to realign its helicopter buys with changes in European stability and security. The country wanted to reduce the number of NH90 troop transport helicopters to 82 from 122, but a long-standing need to replace the aging Westland Sea King resulted in 18 naval versions being purchased, bringing its total NH90 buy to 100 helicopters with 22 options. The deal was finally signed in June 2015, and Airbus has quickly spun up production of the Sea Lion, ready for a 100-hr. flight-test program to run through 2017 and 2018.

But Germany has struggled with the NH90. As the initial customer for the aircraft, it was the first to face the spares shortages and reliability problems that have dogged its early years of operations. It is also facing issues with having aircraft in initial operational capability (IOC), IOC+ and full operational capability (FOC) configurations.

And although the army now operates all of Germany's TTH—Tactical Transport Helicopter—model NH90s aircraft originally destined for the air force which have an additional multifunction display in the cockpit and flotation gear, the aircraft planned for the army do not. The result is that the army is operating NH90s in number of configurations. IOC and IOC+ aircraft are being retrofitted into the FOC configuration. However, officials say the differences are of little concern and created only a minor additional maintenance burden.

"Availability and reliability are improving on the NH90, but it is still not where we want it to be," says Uwe Gebauer, the NH90 program manager at the defense procurement office. "What we are seeing is that the FOC aircraft are much more reliable and stable," he says.

The German defense ministry wants a significant uptick in flying rates, to almost double them to 55,000 in 2023 from 28,000 in 2016. Much of this will be driven by the NH90 fleet.

Berlin must also decide on other major helicopter programs in the next two years. A tender to replace the Westland Lynx Mk. 88 shipboard anti-submarine helicopter likely will be launched in 2017 or 2018, says Capt. Matthias Potthoff, the commander of the German fleet air arm. The acquisition process needs to begin to allow first deliveries in 2023 "in order to begin training," so the Lynx can be retired in "2025 sharp."

TONY OSBORNE/AW&ST

The helicopters, first delivered in 1981, also registered poor availability rates and needed substantial engineering work to address tail boom cracks. Airbus plans to offer a fully capable version of the Sea Lion with a sonar and the ability to drop torpedoes, while Leonardo is planning to offer its AW159 Wildcat.

Germany is also expected to issue a tender early in the new year for replacement of its Dornier-built CH-53 Stallion heavy-lift helicopters. But the choice is limited. With nothing in the heavy-lift class available in Europe, the task will fall to either Boeing's CH-47F Chinook or Sikorsky's CH-53K King Stallion. The rewards will be significant, with any contract likely to be worth about €3 billion ($3.17 billion) for a yet-to-be confirmed number of helicopters. That number is likely to be several dozen, as the selected type must replace 66 CH-53s in service in three derivatives. Deliveries could begin as early as 2022.

Berlin must also consider how to replace the last of its Bell UH-1D rescue helicopters. Of the more than 350 it built during the Cold War, only a handful remain, used for utility and the SAR mission. This could be an additional opportunity for Airbus's H145M light-twin helicopter, 15 of which are being delivered for use by German special forces. The company believes the type could find a wider use with the country's forces.

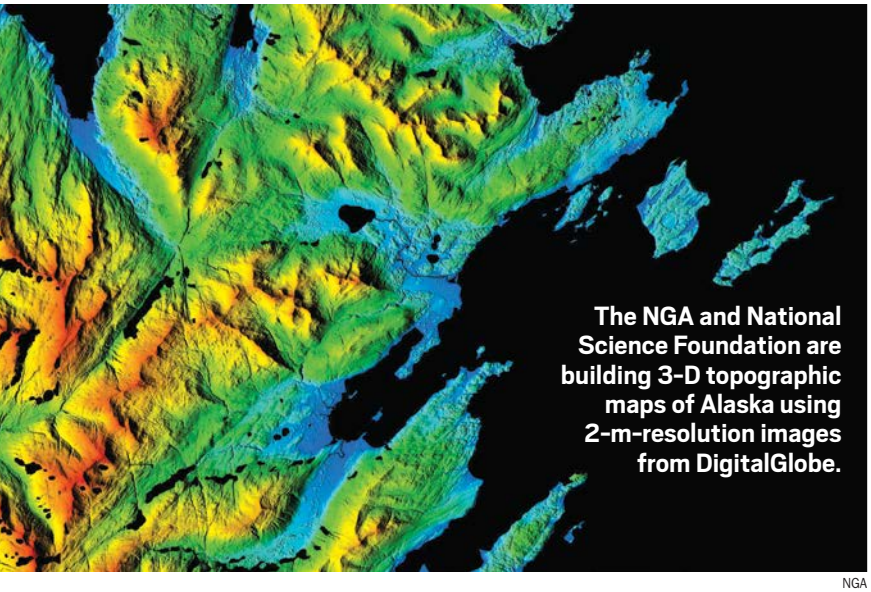
Future Analysis

NGA widens its aperture, prioritizes those who write code

Jen DiMascio Washington

Two years ago, Robert Cardillo, director of the National Geospatial-Intelligence Agency (NGA), began crafting a strategy for the use of small satellites. With that plan well underway, the agency is moving toward a future that has more to do with how data are analyzed, a path he wants to continue under President Donald Trump.

The president-elect ran on the idea that the government is bigger than it needs to be and that entrepreneurs are waiting to unleash their potential, says Cardillo, who is not a political appointee. "I would agree that the government could allow [the commercial] market to do more. And we could let the government focus on what [it] must do," he says.



The NGA and National Science Foundation are building 3-D topographic maps of Alaska using 2-m-resolution images from DigitalGlobe.

NGA

As the head of the NGA, Cardillo is at the forefront of the increasing use of open-source intelligence. And in an environment where the U.S. and its adversaries are all trying to gain the advantage, the key question is one of security. "One of the terms I have been using lately, though it is not fully fleshed out, is counter geo-int," he says.

He points to a map on the wall at the agency's brand-new Springfield, Virginia, campus. "That looks like a real image from space. It looks natural. It looks OK. But if you were going to use it to land Marines, and you wanted to look at the beach and see if that breakwater is there, it's very important in terms of how much weight you put on the craft," Cardillo says. "Is that a true image? Did someone put something in the image to create misunderstanding? That's part of counter geo-int."

Since the U.S. is no longer the only country with Earth-observation prowess, "How do we inform those who want an advantage to understand how the adversary could be using the same capability against us?" he asks.

With imagery about weapons, military movements and research and development activities proliferating, the challenge will be how to best sift through the mountains of data flowing in from various sources. "I think the advantage is going to [whoever] can write the best algorithm, software model application to find what I call coherence from chaos," he says. And as the agency looks to speed data analysis, its future approach and workforce will need to dramatically change, Cardillo says. In the past, the NGA required imagery analysts who could identify specific aspects of certain pictures. Now, the agency prizes the ability to create algorithms that can work through a mass of images at a rapid clip.

"I have begun to talk about the idea that everyone at the NGA needs to be a coder," he says. If not writing code at every position, employees should at least be conversant in the language of coding. "The agency's value will be derived so much from how good we are at it that it just needs to get into our DNA."

The NGA and the University of Missouri have signed a five-year $12 million contract for data science classes, and the NGA workforce is flocking to learn, he says. In addition, Cardillo is continuing the NGA's outreach with commercial and startup companies.

The agency and the National Science Foundation are using DigitalGlobe's 2-m-resolution (6.6-ft.) imagery to build the first publicly available, high-resolution, satellite-based 3-D elevation maps of the Arctic. The models, scheduled for release this year, will replace previous maps that were collected by aircraft and therefore limited by the harsh climate.

And the NGA is seeking new sources of imagery. Last fall, it signed a seven-month $20 million contract with Planet for multispectral imagery at 3-5-m and 6.7-m resolution. Planet will provide unrectified and orthorectified images, or images that remove distortions. The company will also provide orthomosaic single-pass tiles.

The NGA uses commercial imagery for a variety of missions—for example, during natural disasters or to spot drug trafficking. It is also helping monitor the flow of refugees into Europe—not because the movement of people is an intelligence matter in itself, but because the influx of migrants can impact stability in a country or put a strain on infrastructure. "It is up to Planet as to how they are going to build out their [business] model. But maybe they are going to get in the business of identifying refugee camps. I will just tell you here are the thresholds that are meaningful to me. I will pay you every time you send me a cue" to investigate further, Cardillo says. "That is a model I think we will explore. We'll take any company that gets into that business."

Ultimately, working with the commercial sector is changing how the NGA works with the National Reconnaissance Office (NRO) for imagery but not ending the partnership. The revolution in commercial imagery allows the NRO to narrowly focus on particular hot spots, such as monitoring Iranian compliance with its nuclear agreements. The NRO will still be pushing the boundaries with its satellites, perhaps making them smaller and faster. "I won't say cheaper," Cardillo says.

Buying Time

Despite positive aspects to Emirates' A380s deferrals, the program's overall outlook is worse

Jens Flottau Frankfurt

Emirates' late-December decision to defer deliveries of 12 Airbus A380s was widely discussed in the industry as another sign of the slow demise of Airbus's highest-profile aircraft program. While that interpretation may eventually prove true, the agreement—though initially painful—is also a tool that gives Airbus more time to increase its orderbook.

With 142 firm orders and 90 in-service aircraft, Emirates is by far the A380's biggest customer, with purchases of almost half of total production. Its share of the backlog is officially also almost 50%—but unofficially much higher, given that many of the other orders listed are highly unlikely to ever materialize. Therefore, any hiccup in the Emirates delivery process will be a big concern for Airbus.

The reality is that Emirates is pushing out deliveries of six aircraft from 2017 to 2018 and another six from 2018 to 2019. The upshot is that Airbus is producing six fewer A380s this year, but the number for 2018 is not planned to change unless further deliveries are postponed. And the deferral actually makes it easier to keep the planned 2018 rate of 12 aircraft in 2019—a year which had wide-open gaps in production.

Airbus has not said how many A380s it plans to build in 2017 and will not reveal its latest guidance until mid-January. But the figure will likely be well below the 20-aircraft mark it has targeted as break-even, so it will have to reduce production faster than hoped. Emirates says it will still take delivery of a double-digit number of A380s in 2017 in spite of the deferral, but it is not being more specific. Qatar Airways and Etihad Airways are also lined up for deliveries of at least one A380 each this year.

There is little official clarity as to why Emirates made the unprecedented decision to defer the introduction of more A380s, the airline's signature aircraft model. A statement that the move was preceded by an agreement between Rolls-Royce and Emirates, followed by an agreement between Emirates and Airbus, indicates that recent issues surrounding the introduction of the airline's first Trent 900-powered A380s played a role. First delivery of the Trent-equipped A380 to Emirates was delayed several weeks amid talks aimed at resolving apparent contractual issues and performance guarantees. The airline finally took the aircraft—and two more—in late December.

The vast majority of the carrier's A380 order backlog is for the Rolls-powered version, with 52 aircraft expected to arrive in the coming years.

But another aspect should worry Airbus much more. Although Emirates is not specifying its motivation, the airline likely had slower capacity growth in mind. In addition to the 10-plus A380s it is still introducing this year, it will also take a double-digit number of Boeing 777-300ERs. While it is retiring older 777-200ERs and 777-300s, the carrier will not be able to avoid significant capacity growth regardless.

And that is the last thing it needs in the current environment—Emirates has seen yields collapsing and premium demand from oil economies dwindling, while rivals Qatar and Etihad continue to grow. Turkish Airlines also is focusing even more on low-yield connecting traffic from the Middle East, given troubles in its home market. All factors combined have already led Emirates' net profit to collapse by 75% in the first two quarters of its fiscal year 2016, which ends in March.

Airbus must be concerned that the weakness will continue for much longer and that Emirates may defer deliveries yet again. The weakness is also affecting other A380 customers in the region—Qatar and Etihad with four and two aircraft, respectively, yet to be delivered, not to speak of potential customers in good times now bracing for the next cyclical downturn.

The combination of further Emirates deferrals, overcapacity in the widebody market and a delayed recovery of demand could prove fatal for the A380. That is because beyond Emirates, a big portion of the remaining A380 backlog is already shaky: 20 aircraft for A380 specialist lessor Amedeo have yet to find airline homes; three aircraft are still listed for defunct Russian carrier Transaero and two for Air France, which has said it will not take them.

Qantas also has no interest in taking eight more A380s it has on order, and the same is true for Virgin Atlantic, which still holds commitments for six. Hopes that Iran Air would come to the rescue by ordering 12 A380s were dashed earlier this month after the airline opted to drop the idea and instead focused on smaller models.

While Malaysia Airlines seems to have found a new role for its A380s as high-capacity transports for pilgrims to Mecca and will not phase out its entire fleet of six aircraft, Singapore Airlines has decided not to extend the leasing contract for its first A380 and is expected to soon do the same for four more aircraft. Relatively cheap secondhand aircraft will make it even harder for Airbus to market new ones. And as the large Emirates fleet ages, the problem will become much worse over time.

TONY OSBORNE/AW&ST

Emirates' decision to defer 12 Airbus A380s is yet another blow to the struggling program.

Build Up

First GE9X turbofan set for early icing tests as assembly of initial certification engine begins

Guy Norris Los Angeles

Buoyed by promising performance results from runs of the first GE9X development turbofan, General Electric Aviation has started assembly of the initial test engine for the certification program.

Manufacture of the first production-configured powerplant for Boeing's 777X flagship twinjet aircraft also comes as GE completes key endurance tests in a GEnx-1B donor engine of lightweight, heat-resistant ceramic matrix composites (CMC), which are pivotal to achieving the performance design goals of the 105,000-lb.-thrust GE9X.

As exclusive engine supplier to Boeing for the 777X, GE says the positive results of both the initial precertification GE9X tests and the materials evaluation are vindication of its early run strategy to reduce risk and provide margin ahead of Boeing's new airliner test program. The GE9X demonstration engine first ran in late March, while CMCs have been running in both a GEnx test engine and a GE9X core since 2015. The first variant of the new big twin, the 777-9, is meanwhile not due to begin flight tests until the end of 2018.

The first GE9X is at GE's Peebles test site in Ohio, where the company hopes the weather will soon turn cold enough for preliminary natural-icing tests to be conducted well ahead of certification evaluations planned in Canada for late 2017 or early 2018. During Phase 1 evaluations, the engine ran for more than 167 hr. and for 213 cycles as part of extensive tests that have already taught useful lessons to the developers as they prepare for the start of certification, says GE9X general manager Ted Ingling. "We have the ability to keep using that vehicle. Other programs also did this early in the game, and this is repeating that good practice to make sure everything is ready to go," he adds.

"We have just finished detailed design and are now building the first certification engine. From a schedule point of view, we are a little ahead of Boeing by design," says Ingling. "We finished up Phase 1 of the FETT [first engine-to-test], which covered the mechanical checkout. It was spot-on in terms of performance, acoustics and emissions. We are making sure we understand the system operations are what we expect them to be and that the architecture is set up the way we want it." The first engine "is really to make sure some choices for bearing placement and the thermal system—all the hard parts to sort out—are done early, so we had a chance to check it out. That still gives us a chance to put any changes into the second engine for certification. It gives us an opportunity to start in a stable configuration," he explains.

GE AVIATION

With a 134-in.-dia. fan, the GE9X is the largest turbofan ever made.

Describing the FETT as a "huge confidence-builder," Ingling notes that the work on the initial engine did unearth some issues. "We had some pretty modest things we had to change, but they're the kind of things we learn on every program," he says. These included revisions to the nozzle area for the core and fine-tuning clearances. "We can do all the modeling and projection we like, but it is a pretty tough calculation without an anchor to get the correct clearances right out of the gate. It was literally a handful of things that needed to be changed. Other than that, it has performed flawlessly," he reports.

The first certification engine is set to begin running in early April 2017, and will be the first of eight GE9Xs in the program. The hope is for FAA Part 33 clearance in the second half of 2018. Meanwhile, the fourth GE9X will be the first of the enormous new engines to become airborne when it begins tests in the third quarter of 2017 on GE's Boeing 747-400 flying testbed. "The aircraft is modified and ready, and Boeing has provided the hardware," says Ingling, referring to the 19-ft.-long pylon adapter that will connect the 134-in.-fan-dia. engine to the wing.

Boeing is designing the inlet with participation from Spirit AeroSystems, and expects to deliver the nacelle for the flying testbed engine in mid-2017. Boeing also finished testing on the nozzle in early October.

Given the extraordinary size of the GE9X and its 178-in.-wide nacelle, GE is acutely aware of the dangers of runaway weight growth. "Together with Boeing we took a look at the first engine and weighed it," says Ingling. Although testing could still uncover issues that might add weight, Ingling is sanguine. "We've taken into account lessons learned when weight creep happens," he notes.

GE also has completed inspection of representative GE9X hot-section parts made from CMCs after a second phase of endurance tests in a GEnx-1B. Following an initial 2,800-cycle test of CMC combustor liners, turbine shrouds and nozzles, the same parts were later subjected to a further 1,800 cycles. "But this time we injected a more harsh dust environment," says Ingling. "We created our own composition of dust and debris that replicates the corrosive environment we see in some areas, as well as the silica we see in others. This will evaluate detrimental effects such as plugging cooling holes and insulating the wrong side of cooling surfaces," Ingling adds. "The next round of testing will be on a dedicated GE9X. CMC is everything we thought it would be."

Slot Strategies

Tokyo airport proposals offer opportunity for JAL and ANA

ANA

Adrian Schofield

While Japan's two major airlines are planning relatively modest international growth in the short term, expansion could surge again if ambitious efforts to boost Tokyo airport capacity are realized.

The heads of All Nippon Airways (ANA) and Japan Airlines (JAL) are cautious in their growth expectations for the next fiscal year, which begins April 1. However, new opportunities could emerge beyond that. The government has set a policy goal of dramatically raising overall visitor numbers by 2020, which has prompted a range of initiatives to add more slots at Tokyo's Haneda and Narita International airports.

Air service expansion in Japan is linked closely to slot availability at the Tokyo gateways. ANA in particular has completed a period of rapid international growth based on new slots that authorities had previously granted at Haneda.

This trend was illustrated by ANA's 12% year-on-year international capacity growth in the six months through Sept. 30—its fiscal first half. However, capacity expansion will slow in the second half, resulting in a rise of just 7-8% for the full 12-month period, ANA CEO Osamu Shinobe told Aviation Week recently.

This rate is down from the capacity increases of more than 10% the carrier has seen in the past few years. While ANA is still finalizing its plans for the next fiscal year through March 2018, the growth target will be about the same as this year's, Shinobe says.

One reason for the lower growth rate is that Haneda Airport is once again at capacity, says Shinobe. The new tranches of international slots that were made available have been allocated, and no more are yet scheduled. This means that ANA's growth next fiscal year will be mainly focused on Narita. While there are still opportunities for additional flights at that airport, peak hours are close to full.

At Haneda, the government is hoping to lift the arrival rate by changing airspace restrictions over downtown Tokyo. Narita is redesigning runway exits to improve capacity, and has also proposed easing nighttime curfew requirements. Longer-term, it hopes to extend one runway and build another. Public consultations have begun, but many more will be required due to the controversial nature of most of these measures.

More clarity on ANA's growth strategy will emerge when the airline releases an update to its rolling four-year business plan early this year. This will cover fiscal years 2017-20.

The carrier's aircraft delivery goal has already been set. ANA is due to receive six Boeing 787-9s in international configuration in the fiscal year through March 2018. This will give it 27 -9s, leaving another 17 to be delivered. ANA also operates 36 Boeing 787-8s.

However, not all of these aircraft fall in the growth category, since the -9s are also replacing older aircraft. While ANA needs to retire some Boeing 777-200s from its domestic fleet, it wants to use the -9s for international markets. So in certain cases -9s will take over from 777-200ERs on international routes, allowing -200ERs to replace retiring domestic aircraft. ANA is also replacing 767s on international and domestic routes.

All Nippon Airways and Japan Airlines are both receiving more Boeing 787-9s in coming years.

Meanwhile, JAL Chairman Masaru Onishi says his airline does not intend to dramatically ramp up its own international expansion in the fiscal year beginning in April 2017. It will instead aim for "steady growth," Onishi told Aviation Week. The carrier increased its international capacity by just 0.8% in the six months through Sept. 30, and 5% in the previous fiscal year.

Further detail on JAL's intentions will come when the carrier releases a new version of its five-year medium-term plan, which is anticipated in the February time frame.

Indications of conservative growth can be seen in JAL's aircraft delivery forecast. For the next fiscal year beginning in April, JAL is only due to receive three aircraft in its mainline fleet—all 787-9s. This will boost its fleet of -9s to 11, leaving nine more to be delivered. JAL has already taken delivery of all 25 of its 787-8s.

The carrier is scheduled to receive the first of its Airbus A350 orders in 2019. These will essentially be replacements for older Boeing 777s, although the A350s could also be used for fleet growth if the timing of 777 retirements is delayed. Such a decision will depend on market conditions closer to delivery. JAL has ordered 18 A350-900s and 13 -1000s, with options for another 25 aircraft.

While more growth at Tokyo's airports will be needed in the future, the recent expansion of international slots at Haneda has created a temporary supply imbalance, Onishi says.

Airlines from both Japan and overseas have vigorously sought the new international capacity that has been allocated at Haneda. This has led to a relatively quick increase in flights at the airport, creating "a gap between supply and demand," says Onishi.

It will probably take a couple of years for demand to fully catch up to the new services, Onishi estimates. It is widely recognized that the slots will be more valuable in the future than they are now, making carriers anxious to secure them while they can, he says. Airlines must make use of slots they have been granted due to Japan's "use it or lose it" rules.

Onishi welcomes long-term moves to increase slots at the Tokyo airports, and says JAL would probably seek additional capacity if it is made available. However, he cautioned that it is also the airline's duty to make sure that any capacity increase matches demand.

Japan needs to consider Narita and Haneda as a single airport system, Onishi says. Each airport alone will not be able to compete with rising Asian hubs, but they can in combination. For this reason, improved direct links between Haneda and Narita should be developed, such as high-speed rail.

Onishi points out that airport and airline capacity is not the only bottleneck holding back visitor numbers. Insufficient hotel capacity is a potentially larger problem, he says.

Precision Paths

Israel deploys performance-based navigation to mitigate rocket threats and noise issues

John Croft Washington

Israel's airspace is tight and complex. Military operations areas and the occasional conflicts with its neighbors can make the smooth, predictable flow of civil traffic tricky. But new and novel uses for efficiency-boosting performance-based navigation (PBN) procedures are being applied with promise.

More to the point, the precisely defined narrow paths used in required navigation performance (RNP) approaches, a type of PBN procedure, can steer aircraft away from noise-sensitive areas or allow the country to keep all runways at its main international airport, Ben Gurion, and others open during conflicts. The procedures, which are tied to avionics performance rather than ground-based infrastructure, also could aid community relations by helping to curb runway activity in noise-sensitive areas in the compact country, where the military controls most of the airspace.

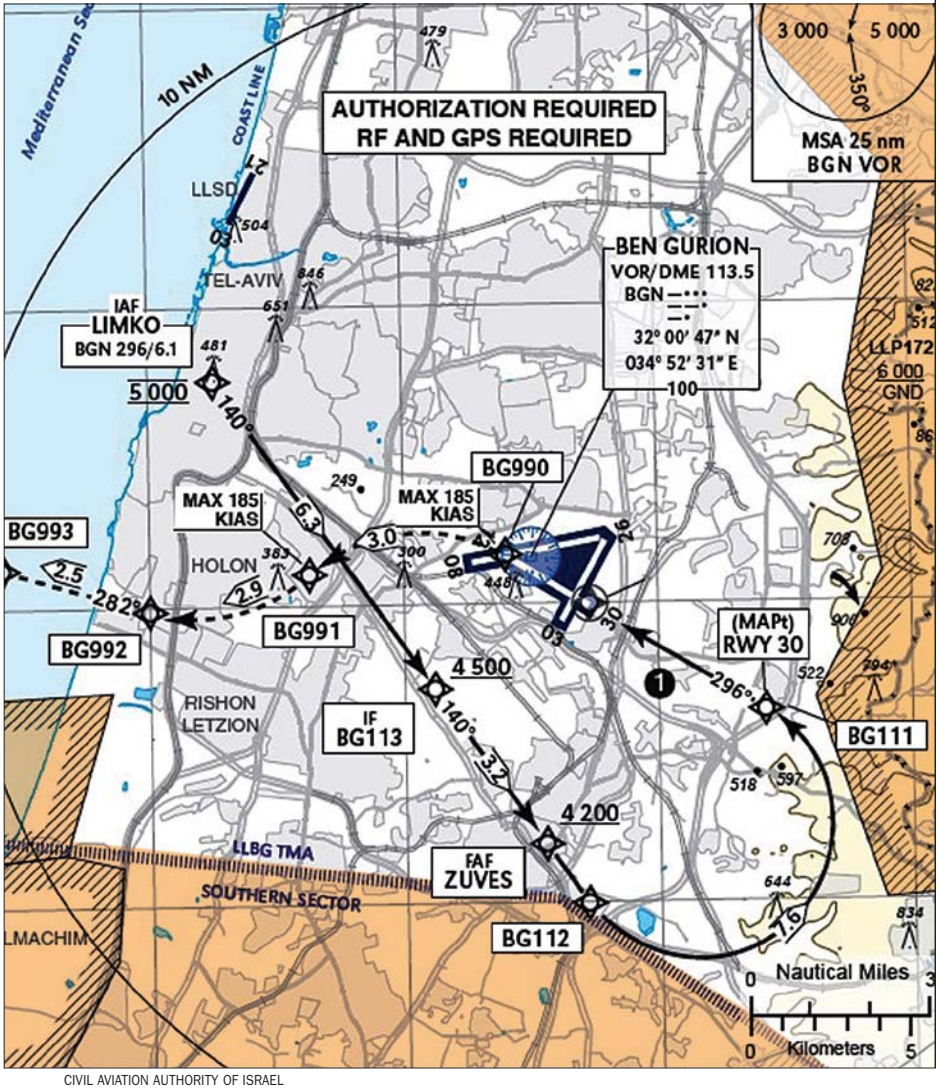
From a military perspective, an advantage of RNP is that it can precisely define routes to avoid major cities so the air force, if ever called upon, could use its Iron Dome interceptor system to destroy any incoming rockets and mortars without fear of striking a civilian aircraft.

"In times of conflict, RNP allows the aircraft to [avoid] major cities, areas Hezbollah and Hamas [would] very much like to target," says Libby Bahat, head of the aerial infrastructure department for Israel's Civil Aviation Authority (CAA), of the country's enemies to the north and west, respectively. "Iron Dome allows the air force to defend those cities and yet allow normal traffic and normal civilian aviation to go into Ben Gurion [Airport]."

The CAA in November declared operational the country's most precise PBN procedure to date: an RNP authorization-required (RNP-AR) approach designed by Houston-based third-party air navigation services provider Hughes Aerospace Corp. The RNP-AR to Runway 30 at Ben Gurion, which is near Tel Aviv, is a procedure that requires an airline to obtain special approval from regulators. It replicates a straight-in instrument landing system (ILS) approach with vertical and horizontal precision guidance but adds the element of curves. Other PBN procedures in use at Ben Gurion are less precise.

The Runway 30 RNP-AR features "radius-to-fix" turns that guide an aircraft arriving from the west through a teardrop-shaped pattern over the ground to remain clear of military airspace to the south and east of the airport. The approach has vertical guidance and minimums of 280 ft. above the runway, twice as low as the previously available RNP approach to Runway 30.

The RNP-AR has other benefits. Chris Baur, president of Hughes Aerospace, says use of the approach, which took two years to develop in large part because of the complex airspace, also reduces track miles and saves fuel. He explains that the RNP-AR's radius-to-fix design offers better "containment" than legacy RNP procedures, an important element given the strong winds that typically blow eastward from the Mediterranean Sea. Baur says the CAA validated the approach with Hughes in a Boeing 737 simulator in Houston and later at Ben Gurion, us-



CIVIL AVIATION AUTHORITY OF ISRAEL

A new curving RNP approach to Runway 30 at Ben Gurion International is designed to separate incoming civilian aircraft from military airspace and noise-sensitive zones (beige areas) south and east of the airport.

ing its Cessna Citation Mustang light jet.

Israel began deploying the PBN procedures in 2013 following a renaissance of sorts within the CAA, ignited by the FAA's downgrade of the country's safety ranking to Category 2 from Cat. 1 in 2008. "It was a very good move in the aviation history of Israel," says Bahat of the changes spurred by the FAA action. Along with updating 80-year-old aviation laws that apparently were in place under the British Mandate before the country's founding in 1948, the CAA tripled its workforce to 120, adding "younger people from the industry that were still flying and knew the business very well." The FAA restored Israel's ranking to Cat. 1 in late 2012.

"One of the steps we did at an early stage was to explore PBN procedures," notes Bahat, "not only for Ben Gurion, but for the entire route structure for the country." The CAA published its first PBN procedure in 2013 and one new approach to a runway about every six months thereafter. In an unusual move, Ben Gurion asks aircraft to use Runway 30 and only with a PBN approach between 11 p.m. and 1 a.m. "We received many requests to allow non-PBN airlines to use the airport at that time, and we refused," says Bahat.

In times of conflict, RNP allows aircraft to [avoid] major cities

The CAA already has published PBN procedures for its new Ramon International Airport near the southern city of Eilat, a facility ideally suited for the technology, as it is surrounded by mountains with large cities nearby. Ramon is scheduled to open this April, and eventually is expected to have an ILS as well. "It will leave a lot of airspace free for Iron Dome and keep Ramon always open," says Bahat.

Whether Ben Gurion or other airports will remain open to international airlines during times of strife is unclear. During the most recent conflict, in July 2014, the CAA kept Ben Gurion open, but the FAA banned U.S. aircraft from flying there for 36 hr. due to concerns over rockets and shelling. The European Aviation Safety Agency followed the FAA's lead and also instituted a short-term ban. According to Bahat, during conflicts, the airport has more operational freedom as its controllers can waive noise restrictions on some approaches.

There are no guarantees that RNP-AR procedures will make a difference for U.S. carriers, which account for about one-third of the traffic at the airport, if similar conflicts occur.

However, Bahat says the CAA is "continuing cooperation with the FAA and the U.S. government in a close, detailed way" and that the U.S. ambassador to Israel, Daniel Shapiro, has been to the airport many times in the past two years and seems knowledgeable about traffic flows and the Iron Dome. "He understands the detailed operational risk analysis that we do and how we can have a very safe civilian aviation and just a couple miles away have Iron Dome protecting a city.

"If I have the FAA confident to keep [allowing] flying to Israel, I will have one big worry off my head," he adds.

View video

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The Quiet Revolution

Ash Carter, Bob Work and Frank Kendall changed how the Pentagon does business

Michael Bruno and Lara Seligman Washington

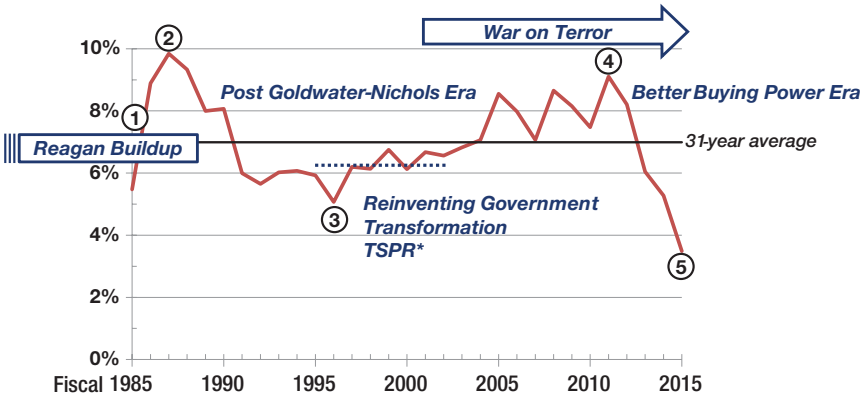
NOTHING MAKES FRANK KENDALL CRY LIKE THE JOINT STRIKE FIGHTER. Sitting in his office in the Pentagon's E Ring, recalling his record-long tenure as the U.S. Defense Department's acquisition czar, he still has the F-35 on his mind—his hair-pulling experience with one of the most complex, troubled and expensive weapons systems ever.

As the undersecretary of defense for acquisition, technology and logistics (AT&L), Kendall has often been on point with the JSF. His office has been where it all meets—the public anger over costs, the frustration over Lockheed Martin's performance and the military's demand for a technological marvel guaranteeing U.S. air dominance for decades to come. →

TECH. SGT. BRIGITTE N. BRANTLEY/U.S. DEFENSE DEPARTMENT

Ash Carter originally had no interest in government work. Then he heard Bill Perry—later a defense secretary—speak about the future of technology in the military.

Contract Cost Growth—Which Reforms Worked?



**Total System Performance Responsibility effort to let contractors be more innovative.*
Note: Five-year moving average, adjusted for inflation, of Major Defense Acquisition Program total contracted costs versus negotiated cost targets.
Source: U.S. Defense Department


GLENN FAWCETT /U.S. DEFENSE DEPARTMENT

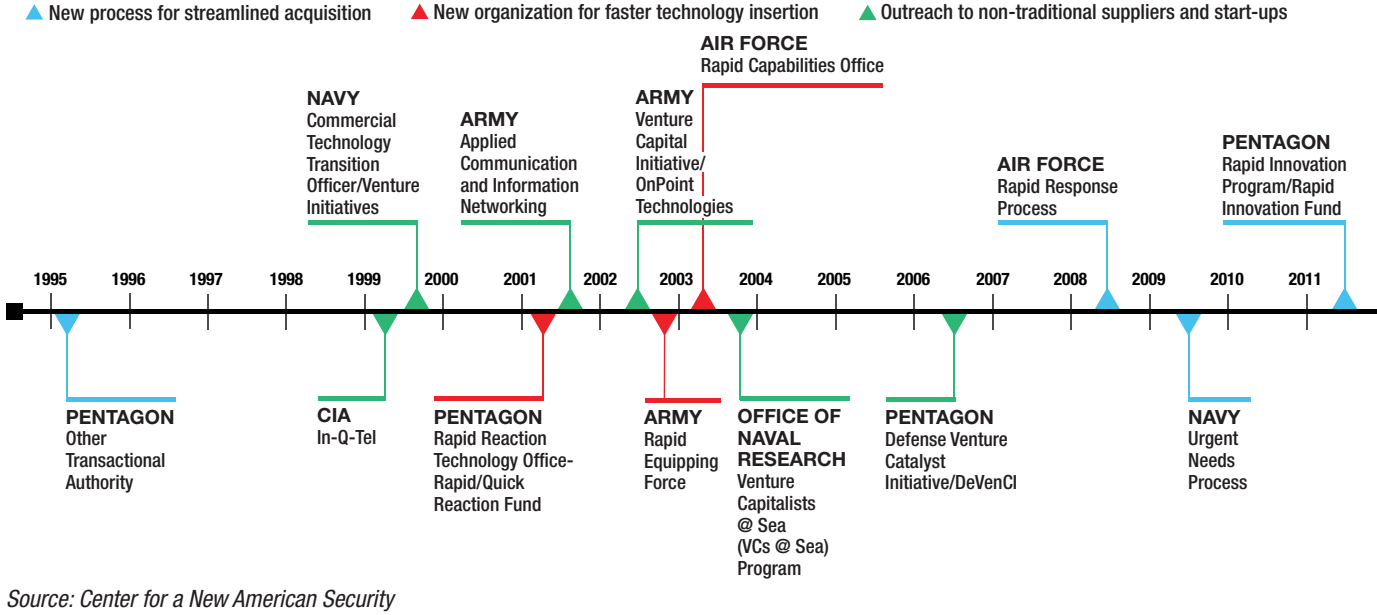
"When I took office, it was my biggest headache," Kendall tells Aviation Week. "Despite the fact that we were a few years into production, we did not have a stable design. We had a lot of issues. I very seriously contemplated stopping production entirely and taking about a two-year gap in production."

Ultimately, Kendall opted to flatten production at 30 aircraft a year for two years while design problems were hammered out. He installed a new program manager on the government side, Air Force Lt. Gen. Christopher Bogdan, a strong leader with an outspoken style (*AW&ST* Sept. 24, 2012, p. 24). And Lockheed made management changes that Kendall now says were a breakthrough.

Today, the program seems to be over its worst days. Initial aircraft have been delivered to most JSF international partners. Feedback so far from operators has been positive.

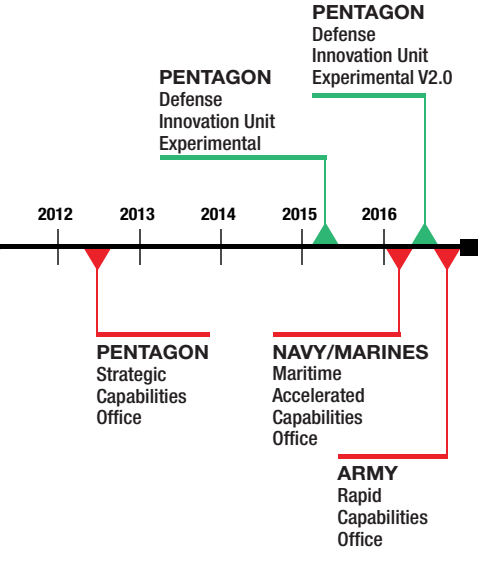
"The highlight of the Army-Navy game for me was not Army winning," says Kendall, an Army veteran. He teared up, but not about football. "It was the four F-35s that flew over my head. It has been a very long, hard

Attempts To Speed Up Acquisition Since 1995



Source: Center for a New American Security

Bob Work's intellect matches his stature, as evidenced by a Third Offset progenitor report at the Center for a New American Security, "20YY: Preparing for War in the Robotic Age," admirers say.



journey [but] well worth it."

For Kendall as well as his predecessor, Ash Carter, now the defense secretary, and Bob Work, the deputy defense secretary, the JSF was not the only grueling experience. The three have flown in formation through other programs' near-death experiences while trying to reform the established U.S. military-industrial approach to technology and operations. While their efforts promise benefits to warfighters and taxpayers alike, they have upset some in the industrial establishment. Agree or disagree with what they have done, their impact is undeniable. For these reasons and others, Aviation Week recognizes the Defense Department's top three officials, Ashton Carter, Robert O. Work and Frank Kendall, as the 2016 Persons of the Year.

Examples of their efforts include how the tortured KC-X acquisition became the Air Force KC-46A aerial refueling tanker, with prime contractor Boeing forced to invest more in its success, and how the Air Force B-21 stealth bomber competition was restarted, awarded to Northrop Grumman as a model "should-cost" program and survived a high-profile bid protest.

In recent years, so-called Nunn-McCurdy breaches—cost and schedule overruns big enough to trigger legally mandated cancellation threats—have been almost eliminated across major defense acquisition programs (MDAP). Under the Better Buying Power reform initiative, the Pentagon has ratcheted up competition among its industrial base. It has better trained its own acquisition workforce. Through the new Defense Innovation Unit, Experimental, (DIUx) offices, it has instituted an

outreach to the technology sector in Silicon Valley and beyond to bring in new capabilities, personnel and thinking to the department and the defense industry. And the legacy defense contractors are being encouraged to bring more radical and rapid proposals to the Pentagon via the newly unveiled Strategic Capabilities Office (SCO).

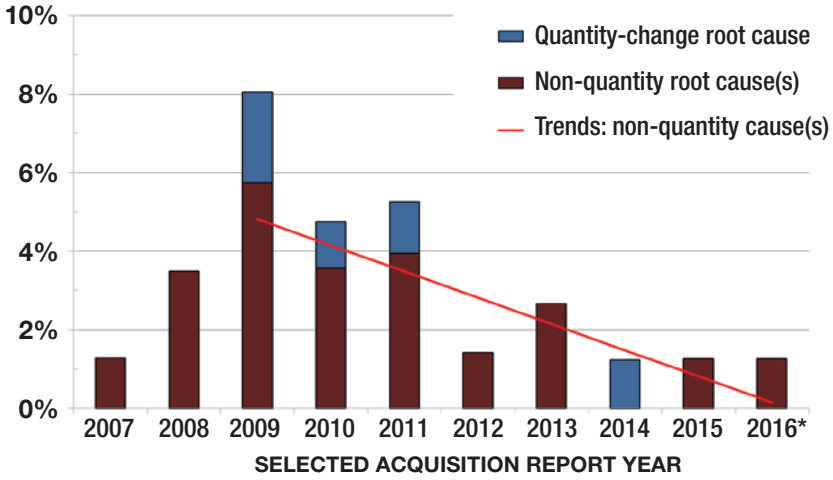
Through Work's craftsmanship, the Pentagon has pivoted to a Third Offset Strategy of pursuing and operationalizing game-changing technologies such as artificial intelligence (AI), human-machine teaming and other innovations to maintain military technological superiority. All of this serves to speed up the hidebound Defense Department and its industrial base—especially via rapid acquisitions—to stay ahead of threats in a decentralized world that moves exponentially faster than it did during the Cold War.

Some of the Carter-Work-Kendall thrusts have roots in earlier defense efforts. But their intertwined experiences, personal chemistry and continuity in office have allowed them to push to the next level.

Most recently, Carter has focused on the high-level institutional aspects of innovation, Kendall on acquisition and R&D and Work on the operational side. But Carter, 62, has held both Work and Kendall's jobs, and he has taught at Harvard University and worked at the Pentagon as assistant secretary of defense for international security policy in the 1990s. He is not just a policy wonk, however. He is also a scientist, with a doctorate in theoretical physics from Oxford University.

A central thrust of Frank Kendall's efforts has been to get new technology—including unmanned vehicles—into the hands of combat personnel more quickly.

SPC. LAUREN HARRAH/DEFENSE VIDEO IMAGERY DISTRIBUTION SYSTEM



** Through second-quarter.*

Note: Fraction of Major Defense Acquisition Programs (MDAP) with critical Nunn-McCurdy breaches (2007–16Q2). Does not include newer MDAPs, which have not spent at least 30% of engineering budget. It is not known whether quantity changes were a root cause of breaches before 2009, as data was not collected.

Source: U.S. Defense Department

Work, 63, is a deep-thinking Marine. He both commanded an artillery battalion and wrote extensively on the future of warfare for Washington think tanks. He served as the undersecretary of the Navy in 2009-13. When he stepped down, he became CEO of the Center for a New American Security.

Kendall, 67, graduated from the U.S. Military Academy at West Point. He left the army as a lieutenant colonel. And he has an advanced-degree "trifecta": master's degrees in aeronautical engineering and business administration, and a juris doctor degree.

Carter says their shared experiences have been essential to their effectiveness. "The ability to give them direction and also support that was informed by the fact that I knew exactly what they were doing and what their responsibilities were," he tells Aviation Week. "That's been a help to me as I've been their boss. But it's a help to them also, I think, to have a boss who knows what you're doing and isn't trying to do it but who backs you up and supports you when you're doing the right thing. That has made us as a team effective."

EVIDENCE SPEAKS

The defense acquisition system can still be improved, of course. Carter, Work and Kendall admit to unfinished business. And, not surprisingly, their reforms and initiatives triggered criticism from upholders of the status quo.

"These measures point to a flawed strategy and assume the solution is related to education, outreach or proximity [to innovators] while missing the essential truth: non-defense companies already know who [the Defense Department] is and what it means to work for a difficult defense acquisition customer, and these companies choose to do business somewhere else," Scott Chandler of the industry-funded Lexington Institute said at a forum last June.

But more often, defense analysts, policy wonks and many aerospace executives have lauded the three for what they have achieved.

"They drove tremendous change," says Andrew Hunter, director of the Defense-Industrial Initiatives Group at the Center for Strategic and International Studies (CSIS) think tank.

"They have been successful," says Steven Grundman, a fellow at the Atlantic Council and a Pentagon acquisition official in the 1990s. "The changes they have put in place will do better than endure—the actual benefit of them will be in greater evidence as time goes on."

Raytheon CEO Tom Kennedy says Carter, Work and Kendall have done a "tremendous job," especially in using the Third Offset to focus the department on technologies such as hypersonics and machine learning to enable U.S. forces to make and carry out decisions faster than their adversaries. "This is good stuff," Kennedy says. "We're on the right road here."

It all begins with numbers. Outside the door to Kendall's office is a plaque that quotes W. Edwards Deming: "In God we trust; all others bring data." Indeed, one of Kendall's proudest, albeit indirect, achievements has been compiling and issuing a now-annual report card called the Performance of the Defense Acquisition System. What started four years ago as just another government report destined to collect dust on a shelf has turned into a must-read magnum opus for industry officials, congressional aides and anyone else with a stake in defense acquisition.

The latest report is full of data and speaks to improvement. Growth of contracted costs for MDAPs like the JSF and KC-46A has dropped overall to a new 30-year low of 3.5% in 2015 from 9% in fiscal 2011 (see graph on page 30). Competitive source selections have increased by half.

Even though bid protests to the Government Accountability Office (GAO) have nearly doubled since 2001 to

about 1,300 annually, the GAO has kept sustaining the Pentagon's work at the same rate. Reversals of contract decisions have been flat at just 2%.

On cost and schedule overruns, the trends are even more encouraging. Nunn-McCurdy breaches have trended downward since 2009 (see graph on page 33). Consulting giant Deloitte says that in 2008-12, the cost of major defense programs increased 51%, while in 2012-15, total MDAP costs grew only 5%. Since 2011, nearly three-quarters of programs in the current portfolio have kept their cost growth below 10%. Before 2011, fewer than half of the programs did so.

Technology has been a hallmark of Carter's leadership tenure, starting in 2009 when he was Pentagon acquisition czar and continuing through his 2011 appointment as deputy defense secretary.

The Pentagon's appetite for new major weapons programs also has been curbed. Deloitte says both the number of programs in the current MDAP portfolio and their total cost is at the lowest level since 2004 (see graph on facing page).

The CSIS's Hunter, whose tenure as a defense official in 2011-14 included a stint as director of the Joint Rapid Acquisition Cell, says this shows that the Pentagon no longer rubber-stamps troubled MDAPs to go forward.

WEAPONS FOR WARFIGHTERS

The key measure of success, however, is putting superior weapons into the hands of warfighters. As Carter, Work and Kendall prepare to leave the Pentagon, their efforts are finally starting to pay off.

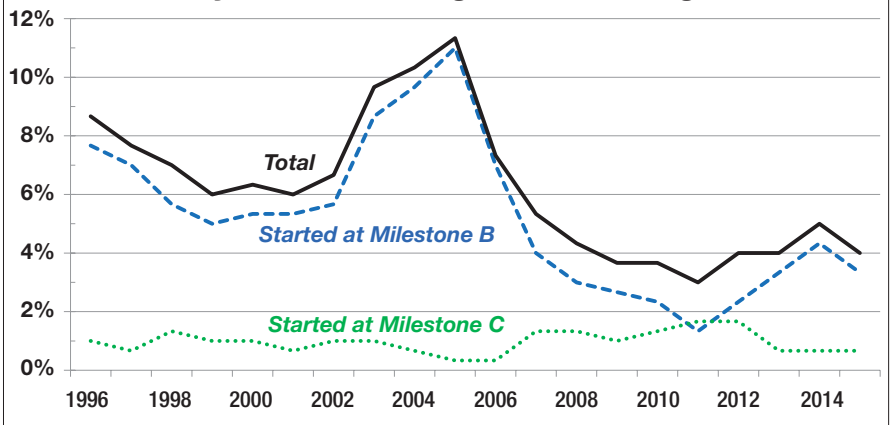
The F-35 had a milestone year, making its first international deployment and reaching initial operating capa-

ARMY SGT. AMBER I. SMITH/U.S. DEFENSE DEPARTMENT

bility for the Air Force's first F-35A squadron. As Air Force and Marine Corps pilots start operating the fifth-generation fighter and discover its unique capabilities, the "trillion-dollar boondoggle" label is beginning to fade.

The JSF remains a hot topic. President-elect Donald Trump criticized the nine-nation, three-variant program's costs in a recent tweet. The program office still is struggling to finish the aircraft's development phase, announcing in December a possible seven-month delay and yet another $530 million increase on top of the roughly $60 billion in research and development funds the government has already spent on the program. Meanwhile, the fighter program continues to wrestle with unexpected software and weapons integration issues.

Major Defense Programs Green-lighted



Note: Data points for 1996 reflect the average for calendar 1994–96.
Source: U.S. Defense Department

But by most accounts, the JSF program has overcome the worst of its design issues, made progress since a critical cost breach and subsequent rebaselining in 2010 and stuck to its original fix-it plan. "Let's put that in perspective," Bogdan says. "[If] anybody would've told us in 2011 that we would be within a few months and a couple hundred million dollars of a $13 billion rebaseline, we'd all have slapped the table and said, 'We'll take it.'"

Boeing's KC-46A tanker is another example of a program that has overcome big hurdles. The Air Force has given Boeing the green light for initial production of the aircraft after months of technological snags and serious schedule delays.

The new stealth bomber, the Air Force's B-21 Raider, is so far another acquisition success story. The Pentagon's 2015 selection of Northrop Grumman to build the new bomber survived a bid protest by a losing Boeing/Lockheed Martin team. In its declassified ruling, the GAO praised the Air Force for conducting a comprehensive source selection process and scathingly critiqued the protest.

HOW THEY DID IT

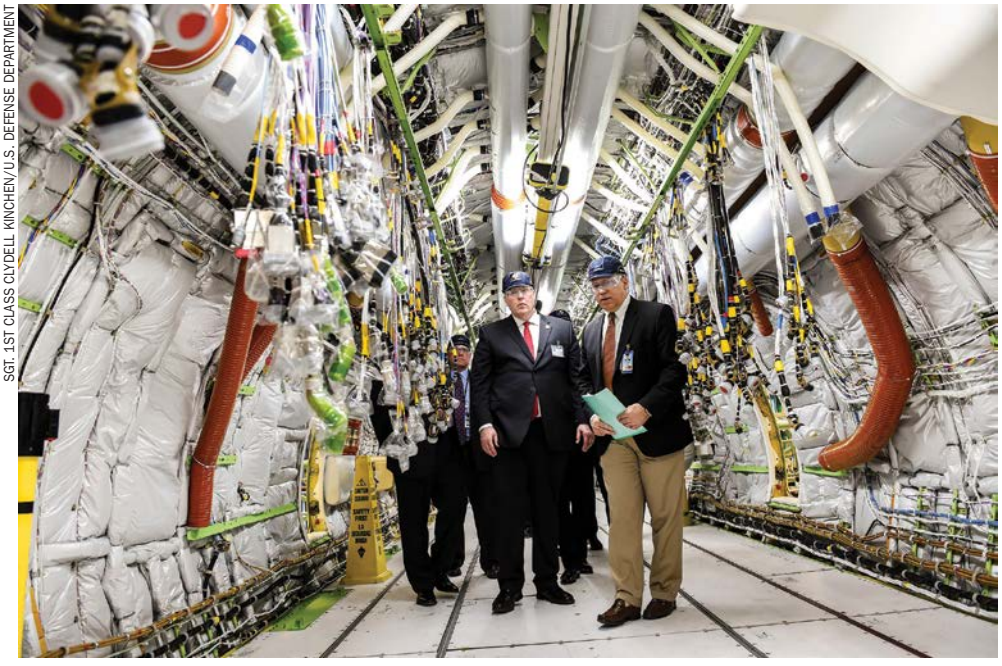
One aspect of the success of Carter, Work and Kendall has been the Better Buying Power (BBP) initiative and related efforts that started under Carter in 2010 and were expanded by Kendall. BBP 1.0, as it is now called, focused on training the Pentagon's own acquisition workforce to be wiser, more accountable buyers and better managers. BBP 2.0 and 3.0 introduced "should-cost" assessments of what the Pentagon buys and emphasized technology insertion in acquisition as well as open architecture in program designs and leveraging competition across the board.

Meanwhile, the DIUx field offices in Silicon Valley, Boston and Austin, Texas, are reaching out to the U.S. tech sector, and Carter has met with entrepreneurs at tech startups and incubators. The DIUx leadership and function were overhauled in May 2016 to reflect the tech community's axiom of "failing fast" to learn and adapt development efforts.

Not only is DIUx's aim to spur nontraditional industries' interest in defense but also to reorient the Pentagon itself toward a more rapid and open development culture. In fiscal 2016, the office awarded 12 contracts, worth $36 million—but just $8 million came directly from DIUx. Initial awards deal with autonomous systems, machine learning and AI, protecting defense networks, commercial space payloads and sensors, and biotechnology.

The reorientation was not uniformly welcomed by established defense contractors, but protests were muted. One reason may have been the SCO, the secret office Carter announced in 2016, which was investigating new offerings from legacy primes looking in part to leverage their existing weapons.

Indeed, the "a-ha!" moment that sparked the Third Offset was when then-Deputy Defense Secretary Carter established the SCO in 2012, Work says. At the time, Pentagon officials were beginning to realize they needed a new approach to address the troubling trends cropping up in the Western Pacific.



SGT. 1ST CLASS CLYDELL KINCHEN/U.S. DEFENSE DEPARTMENT

"I really do feel very honored to be a part of a troika where Secretary Carter had this broad vision of innovation that animated the department," Work says.

"When I came in, I was intent on following up on Secretary Carter's idea of SCO, but making it bigger," Work tells Aviation Week.

The SCO's efforts remain mostly in the shadows, but Carter cites as an early success an offensive capability for the SM-6 over-the-horizon missile. Carter also says the office is upgrading the Army's Tactical Missile System to allow it to strike moving targets on both land and water, as well as working on an airborne "bomb truck" dubbed the arsenal plane.

THIRD OFFSET

The Third Offset is the natural evolution of the SCO, Work says. The strategy aims to use technology to assure U.S. military dominance in the face of asymmetric threats from near-peer adversaries such as Russia and China. Besides AI, autonomy and man-machine teaming, Work has focused on what he calls "deep-learning" machines. Operationalizing technologies for battlefield use is also key. For example, anyone could buy night-vision goggles in 1975, but the Army devised tactics and procedures to make them useful for forces operating at night.

"People say, 'Somebody might be able to get this new technology into the fleet faster than we can,' and I say, 'Who cares?'" Work says. "The amount of time it takes to do the concept, to do the doctrine, to do the training, to do the exercises and become proficient in it—that's what people should look at.

"You have to be prepared for technical surprise," he continues. "You have to have an organization that's agile and resilient, [and] when it is surprised, is able to respond quickly without losing momentum."

To do so, the department must tap into the commercial sector—quickly. Work emphasizes that the threats are various and dynamic: large-state powers China and Russia, medium-state powers like Iran and North Korea, and "non-state actors" or terrorists. The Pentagon can no longer afford to spend many years developing the next great-leap weapons, as it did with the First Offset (nuclear weapons and missiles) and the Second Offset (an array that includes stealth aircraft, precision-guided weapons, networked command and control, and space-based communication and navigation).

Work knows today's game-changing technologies may have a short lifespan in any particular application. So the Third Offset has to be about the culture and speed. "That's why we're saying, 'Let's shoot off on an initial vector, start getting things right,'" he says. "And then we'll reexamine and say, 'What do we have to do?' Because we know we're in a temporal competition."

One example of applying Third Offset thinking is the establishment of the Joint Interagency Combined Space Operations Center, an experimental effort to improve battle management of the U.S. military space constellation. It established battle-management and command-and-control tools to defend the network in space and still provide the level of support that the warfighter needs on the ground.

Another example is the Army's first tactical electronic- and cyberwarfare unit, which is designed to protect Army maneuver forces on the move.

"These are both being infused with new technology; learning machines, human-machine collaboration, advanced visualization, big data analytics, lots of unmanned-manned teaming, new types of autonomous weapons," Work says.

CRITICISM AND RESPONSE

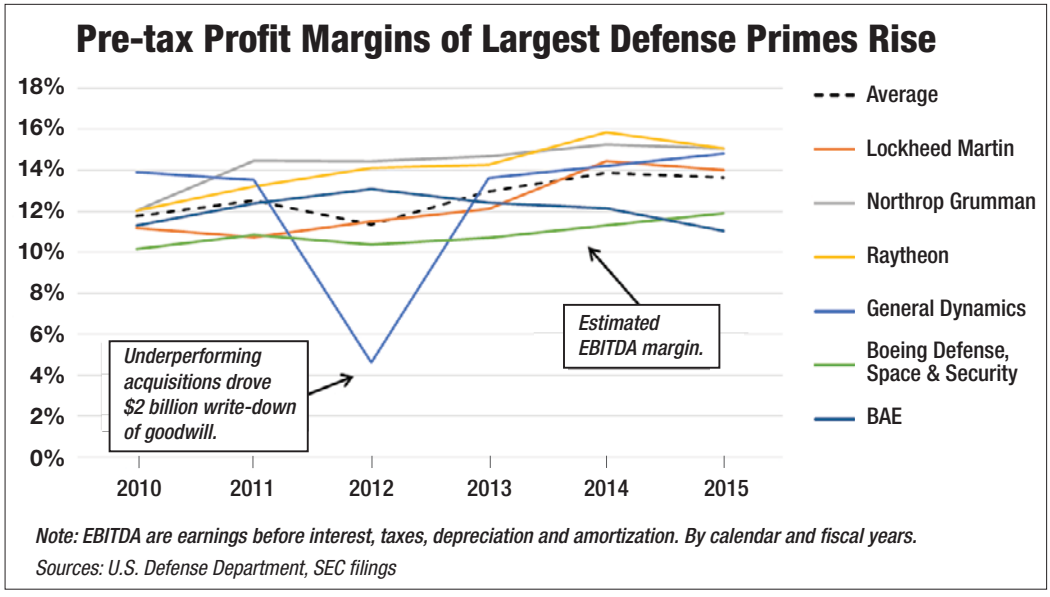
As with the SCO, industry has mostly been a vocal fan of the Third Offset. Raytheon's Kennedy says, "We need to make sure the next administration carries this forward." But some established defense companies have seen the Pentagon trio's efforts—stressing competition, establishing the DIUx, pushing for greater intellectual property access, and leveraging research reimbursements—as an attack on their way of business.

"Despite leadership denials of a war on profit, the visible, practical Defense Department profit policy is to minimize profit apparently at any cost," the Lexington Institute's Chandler says.

Pentagon leaders have always denied that, and industry financial results argue against it, too. Leading primes have seen rising profit margins (see graph on facing page), and the Aerospace Industries Association has celebrated record industry revenues for several years.

"There never was a 'war on profits,'" Capital Alpha Partners defense analyst Byron Callan says.

Industry also has benefited from compromises with Carter, Work and Kendall on many issues. For instance, to work through monopoly complaints about the F-35 and its Pratt & Whitney F-135 engine, the Pentagon started new programs with the prospect of opportunities for other defense companies.



"We are starting follow-on programs to the F-35," Kendall says. "I was able to get something in front of the budget a couple of years ago called the Aerospace Innovation Initiative, which is a classified program, so we can't say much about it. But it is on the road to the next generation of tactical aircraft capability, developing technologies relevant to that."

Carter talks about future fighter-engine development efforts, one result of the "engine war" between the F-135 and the GE-Rolls-Royce F-136 in 2010-11. "The competition we ended up substituting for a competition between two redundant systems was a competition between an engine we were building and an engine that we were developing," he says. "The key there was to get our industry partners to accept that as a way that worked for them as a business proposition."

AARON LEBSACK/DEFENSE VIDEO IMAGERY DISTRIBUTION SYSTEM

A plaque by the door to Kendall's office quotes W. Edwards Deming: "In God we trust; all others bring data."

THE FUTURE

Trump has announced a replacement for Carter, Work is almost sure to be replaced, and Kendall has said he will depart. Will the reforms they have instituted stick?

The future of Kendall's office itself is in doubt. Senate Armed Services Committee Chairman John McCain (R-Ariz.) has pushed for eliminating AT&L altogether and splitting the oversight of innovation and R&D into one job and management of procurement and logistics into another.

"We have put too much under AT&L," says House Armed Services Committee Chairman Mac Thornberry (R-Texas). "It is essentially impossible to make the person who is responsible for buying things efficiently be chief innovation officer."

Last year, Congress took a middle path, keeping Kendall's office but creating a new "chief technology officer" position to focus on innovation and new technology. Implementation of the position is deferred until 2018.

"The research and engineering position is the guy who gets to do the cool fun stuff, and he's allowed to fail as much as he wants to. And the acquisitions and sustainment person is supposed to deliver things to the warfighter and never have a schedule overrun or a cost overrun," Kendall says. "I want the first job; I don't want the second one."

Carter, Work and Kendall expect future defense leaders and presidents to pick up where they leave off, in part because the Defense Department—despite its flawed acquisition and management history—tries to plan and adapt to win.

"It's not just about me," Carter says. "It's about rapid acquisition in response to war. It's about strategic transition from an era where we focused primarily on counterinsurgency and counterterrorism to one where we still have to do that and can't unlearn that but are also turning our strategic and programmatic attentions to near-peer threats.

"In all of those cases, we have learned to do better."

Check 6 *Carter, Work and Kendall's impact on the Pentagon and defense industry—will it last?*
AviationWeek.com/podcast

Interactive Data *See Aviation Week's picks for Person of the Year since 2005:*
AviationWeek.com/POYTimeline

Vertical Vision

After successful tethered tests, VTOL arc-wing configuration targets free-flight evaluation

Guy Norris Los Angeles

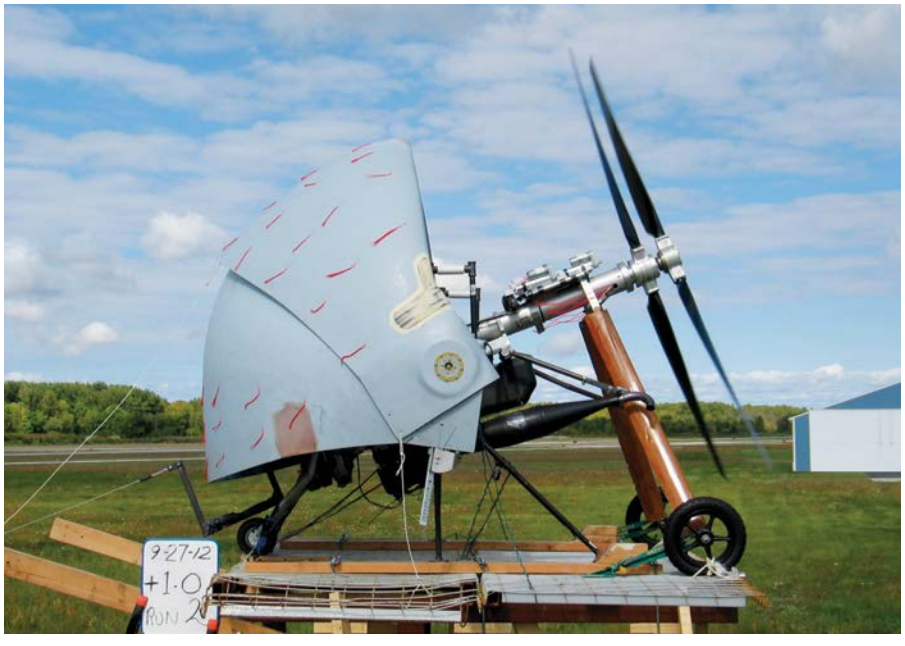
Designers have resorted to complex rotor systems, tilting wings, thrust vectoring or direct lift to master the tricky challenge of combining vertical-takeoff-and-landing (VTOL) capability with high cruise speed. Now developers in Michigan have unveiled preliminary test results of a simpler arc-wing concept that they hope could bring efficient hover and fast cruise capabilities to general aviation with lower cost and complexity.

Bay City, Michigan-based Bertelsen Design has taken the wraps off its recent work on an unconventional aircraft configuration that uses a movable, multi-element arc wing to capture the energy from the deflected slipstream of a large propeller for VTOL and cruise. The company hopes to attract additional funding for larger-scale tests after achieving promising results from initial evaluations of a ground-based research model.

"The intent with this project is to develop technology that is accessible to the general aviation community. It is a little bit lower on the spectrum in terms of complexity and cost," says co-founder and principal designer William Bertelsen. "We believe the multi-element arc-wing system does have VTOL capability right now. And, quite possibly, it also has the potential for efficient high-speed cruise in the near future." The mechanics involved "are simple enough to result in an affordable aircraft for general aviation, and a refined version of the arc-wing VTOL might just be able to outrun any turbine-powered helicopter," he adds.

As its name suggests, the deflected-slipstream concept relies on achieving VTOL by diverting the propwash downward to create upward thrust for takeoff and a cushioned landing. The principle itself is not new and was tested in the 1950s and '60s with mixed results. A notable flight-test campaign conducted by NASA with the Ryan Aeronautical VZ-3RY project, among other attempts, showed short takeoff and landing (STOL) could be achieved but that the design suffered from control and stability issues.

Unlike the planar wing-configured VZ-3RY, Bertelsen's design uses a radial arc-wing geometry consisting of nested shells. "The justification for the arc wing is it is the best geometry for redirecting a cylindrical propeller flowfield," he says. "You get a cylindrical slipstream from this big prop, and the arc wing captures the energy from that, with minimum structure and area." The wing structure is always under tension and therefore light. Canard control surfaces are located right behind the propellers because a conventional empennage would not be effective in the hover. "But there is always air going over the canards," explains Bertelsen. "We have horizontal canards which can be operated inde-



SAE INTERNATIONAL PHOTOS

Arc-wing ground-test vehicle is pictured with inner main arc wing deployed (top) and retracted (bottom) relative to outer slat shell.

pendently to give roll and pitch control and a chin rudder for yaw."

"The Ryan design was good for STOL but was not good at VTOLand had some issues such as adverse ground effect due to some recirculation," he adds. "But the big issue was trim problems due to the migration of the center of force during flap extension and retraction. It was hard to trim for both cruise and hover flight modes." The arc wing hopes to overcome those issues by focusing the wing force vectors through a common center.

"The geometry ensures a focus of those forces during transition as wing elements retract and consolidate," says Bertelsen. "This way, you have a big thrust vector and the sum of all the wing force vectors, and when you add those together you get a vertical component for taking off straight up. So this is the theory, and we just hoped the trim problems could be eliminated. That was never really tested until just recently, and that is one of the reasons we built a model to validate that."

The 6-ft.-span research model was configured with contrarotating propellers 75-in. in diameter. These were driven via a two-stage reduction system and powered by a two-cylinder Compact Radial MZ202 producing 60 hp at 5,800 rpm. The vehicle, weighing 320 lb., was positioned on a wire mesh test platform elevated to a height of 11 ft. "We wanted to see if it could support itself outside of ground effect, so we had to think of a way of simulating that without it really being able to escape," says Bertelsen.

The adjustable, carbon-fiber blades had a disc loading of about 10 lb./ft.^{2}, comparable to the Boeing AH-64 or Sikorsky UH-60. The inner wing weighed just 10.5 lb., while the outer wing shell, which Bertelsen refers to as a slat, was 12.5 lb. The wings were mounted on a tubular spar that was fitted with a release mechanism that, once unlocked, enabled them to rotate.

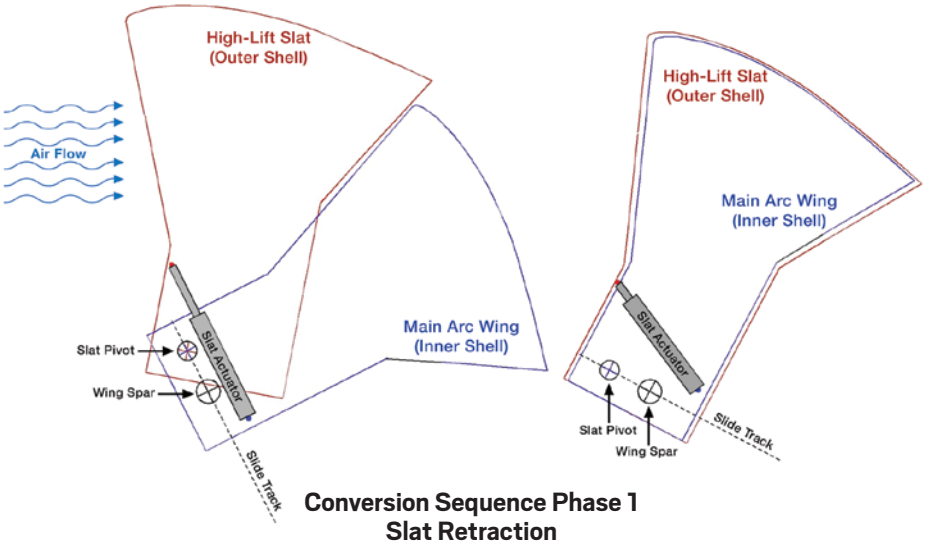
The inner and outer shells were fitted at each end into a channel containing ball bearings that allowed an actuator to slide them back and forward. "Using this [feature], we can shift the entire wing assembly fore and aft," Bertelsen says. "That way we can control the angle at which the arc-wing system stabilizes. The free-rotating wing spar allows it to stabilize itself in the slipstream. If you shift the wing forward, it stabilizes at a higher angle of attack, and if you shift it aft it stabilizes at a lower angle of attack. The ability of the arc wing to stabilize itself in pitch is one of the remarkable things about this nascent VTOL technology. The wing force always passes through the center of the wing spar," he adds.

When deployed, the slat extends forward. "As the slat rotates forward, the spar unlocks and the main wing starts acting as a flap, and you get this slotted-flap effect," says Bertelsen. "The lower actuator drives the whole wing assembly along the slide forward and aft to vary the angle of attack."

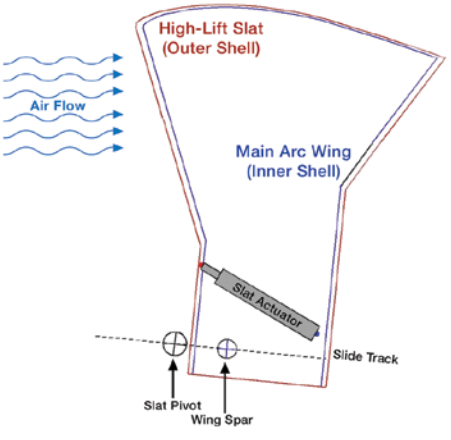
For the first liftoff test, the horizontal canard was removed to "see if the wing system by itself could generate enough lift to get airborne and to see if it would be able to hover without help from the canard," says Bertelsen. With 1,700 rpm on the props, the engine produced 350 lb. of static thrust and zero torque because of the contrarotating configuration. "We soon realized we had enough performance that it might be able to fly on partial throttle, so later we tested with feathering of the throttle. This confirmed we had the pitch of the blades set about right and could hover with no nasty torque reaction," he adds.

Later tests evaluated the VTOL configuration with a fully extended slat set at 51 deg. with respect to the inner main wing shell. This was also the setup for a static conversion test to get from hover to cruise configuration. "We do it with the spar unlocked and free to rotate. The wing rotates and is free to move into the slipstream as it reacts to the airflow from the props," says Bertelsen. He notes, however, that the angle of attack "is pretty high, so to get into the second phase for the cruise configuration we have to shift the wing aft, which then stabilizes at a lower angle of attack."

For the next step, Bertelsen says the focus would be "getting this to operate in free flight." But, despite building and flying a small arc-wing model fitted for forward flight only, testing of a larger test vehicle "is a little bit beyond our capabilities right now," he adds "There is still a lot of work to do. This research model is pretty much a nuts-and-bolts vehicle and is not really optimized. But we think it proved most of the design decisions were correct.



Conversion Sequence Phase 1
Slat Retraction



Conversion Sequence Phase 2
Wing Shift

Video *See video of ground-based models testing the arc-wing concept at* **AviationWeek.com/ArcWing**

BULLEN ULTRASONICS

Jeff Krikenbarger of Bullen Ultrasonics produces a ceramic matrix composite component using a custom-made automated ultrasonic machine.

Manufacturing's Coming Revolution

Ready or not, aerospace factory of the future is on its way and will increase global competitiveness

Anthony L. Velocci, Jr. New York

The aerospace manufacturing landscape is undergoing a massive collective shift toward seamless integration of the digital and physical worlds, with the ultimate goal of interconnecting every process essential to the production of aircraft and other aviation platforms.

This transformation goes by various names—Industry 4.0, e-Factory, Intelligent Manufacturing, Connected Factory. No matter what it's called, however, these terms all refer to the same thing: the factory of the future (FoF). When fully implemented, it will enable companies to be more responsive to` customer demands, achieve greater operational efficiency and speed up product innovation.

It also may help large system integrators improve their track record of poor program performance, including cost overruns and schedule delays, says Tom Captain, vice chairman and U.S. aerospace and defense leader for Deloitte Consulting. "The aerospace and defense industry is following in the footsteps of the automotive industry 20 years ago in terms of coming to grips with how it needs to transform, and the FoF will be key to increasing their efficiency and reducing product development cycles," he says. "It is one of their best chances for producing the next generation of [aircraft and weapons systems] on time and on budget."

Most major airframe manufacturers, and some suppliers, are investing heavily in introducing advanced-factory concepts and technologies into their business. As competitive pressures mount, industry observers believe companies that commit to the digitalization of their factories will succeed, while those that stall or cling to the status quo will struggle.

Prime contractors seem to be moving full speed ahead. However, lower-tier suppliers appear to be in no rush to follow suit. There are exceptions, but a random sampling of C-level executives representing small companies (revenue less than $500 million) attending a recent aerospace/defense conference produced this disturbing admission: All expressed little understanding of what the factory of the future is about, none saw a strong incentive to transform manufacturing systems in the foreseeable future, and some were reserving judgment about whether to move in that direction at all.

"Pressure to increase [commercial aircraft] production rates and improve program performance are the two biggest challenges facing aerospace and defense, and managers no longer can expect to meet these challenges simply by throwing manpower at the problem," says Michel Tellier, vice president for aerospace and defense at Dassault Systemes, which develops 3-D design, 3-D mock-up and product life-cycle management software for the aerospace and defense industry. "Most [large] contractors understand they must transform their operation to remain competitive."

No one knows this better than Airbus. "The factory of the future is very necessary to meet the exponential growth of commercial aviation," says Curtis Carson, head of Airbus Manufacturing Digitalization. "Our production rates are already very high, and as they continue to increase to reflect the doubling of global air traffic every 15 years, our production system needs to have the capability for this growth."

To illustrate, Carson notes that Airbus in 2015 delivered a record 635 commercial aircraft to 85 customers, surpassing the previous year-end record of 629. "To keep up with this inexorable rise in output, we cannot simply make our factories bigger," he says. "Rather, we have to reorganize them to make them leaner, more agile and more connected with smart technologies, extending into our supply chains."

By no means is the convergence of the mechanical and digital ages in lockstep across the supply chain. Manufacturers of all sizes are at different stages of implementing their vision of the FoF. Their immediate task is migrating legacy production systems to distributed and Internet-of-Things-oriented (IoT) technologies and interoperability.

Eventually, devices and machines embedded with smart sensors will provide the raw data, analysis and closed-loop feedback mechanisms to automate and manage process-control systems at every stage of manufacturing. Infrastructure capable of supporting very large data sets and applying machine-learning algorithms will be used to mine the data for specific patterns.

The value will come from gathering and storing the right data. These patterns can be used to derive insights about existing and future operations. Managers will incorporate resulting models into operational workflows, so that as data is received the models will generate projections, forecasts and recommendations for improving production speed and efficiency, as well as

optimizing overall business processes.

For its part, Airbus has chosen two sites representative of its primary commercial aviation manufacturing activities to test and validate the enabling technologies, processes and protocols that will serve as the template for its FoF network, and it is training and educating employees at those sites. Airbus plans to pursue a wider deployment of the system in stages as capabilities mature.

In the near term, Airbus faces two major challenges, according to Carson. The first is the seamless integration of technologies into a production environment. The second is coaxing strategic suppliers to commit to transform their own production systems to align with their customers' connected factories. "We have a vision of where we want to go, but the speed at which we get there will depend on our suppliers," he says. "Just as we are going through a transformation, so must they. We have expectations of them."

The second major challenge is achieving a unified IoT infrastructure involving all participants. All of them need to be linked, able to exchange data generated by countless smart devices and machines in a way that makes the data actionable.

"Standardization of data interfaces and hardware connectivity is an urgent topic," says Tellier. The large system integrators are leading the effort to define those standards, but there is a great deal of work left to accomplish, he adds. "The factory of the future is predicated on all these companies being able to work together, but currently there is a marked inconsistency in operating systems and protocols."

Airbus expects its FoF initiative to eventually lead to lower recurring costs, higher quality and the ability to significantly increase production rates. "We do not know the full potential yet, but we are already finding new ways to support the business with what we have done thus far," Carson says.

The potential Lockheed Martin sees is the opportunity to improve the affordability of weapons systems, accelerate development of new ones and increase manufacturing agility, according to Jeff Wilcox, vice president of engineering and program operations. "The ability to seamlessly swap out or rapidly insert new technology into systems in production or in design will be a key discriminator in the future," he says.

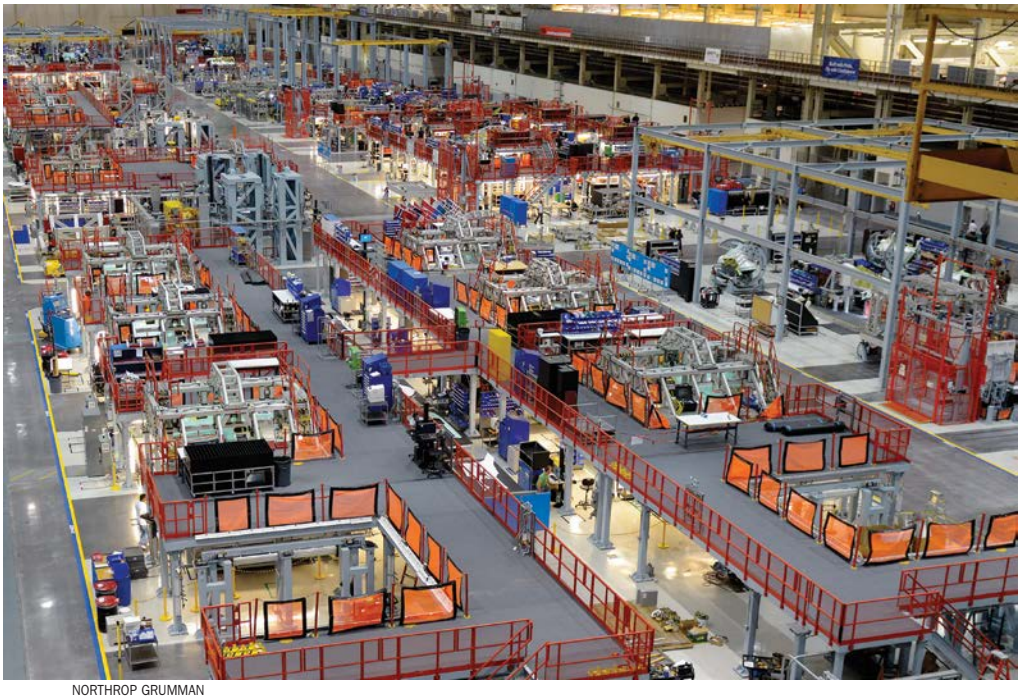
Lockheed Martin is approaching the broader initiative from the standpoint of transforming not just how something is produced, but also how it is designed. "We are thinking across the enterprise and how the factory of the future—with all of its advanced technologies—will look 10 years from now," he says. But first the company must build the digital infrastructure that can support the company's vision of the FoF, he notes. "Getting that right is job No. 1," he says.

As critical enabling technologies mature—each evolving at a different rate—Lockheed Martin will "harvest" and use them to take advantage of the unique contributions they can make to manufacturing operations now, according to Wilcox.

As for suppliers, Wilcox, who chairs the Technical Operations Council for the Aerospace Industries Association, prefers to frame Lockheed Martin's expectations more in positive terms set against the consequences of eschewing the FoF. "They have an opportunity to work with us in the development of technologies that will be critical to the factory of the future," he says. "Companies that come to the table earlier and integrate into our evolving enterprise will have a tremendous competitive advantage in the marketplace."

His advice to companies throughout the aerospace supply chain: Engage in the dialog about the FoF, whether it is through trade associations, other groups or in direct communications with OEM customers. "I strongly encourage smaller companies to get involved with the National Network for Manufacturing Innovation (NNMI)," he says. NNMI, perhaps better known publicly as Manufacturing USA, seeks to find solutions to advanced manufacturing challenges and increase industrial competitiveness by connecting people, ideas and technology.

Among small suppliers, Bullen Ultrasonics is one of the exceptions, wasting no time in embracing the FoF. The small Eaton, Ohio-based company does ultrasonic machining of hard, brittle materials, such as ceramic matrix composites, for jet engine manufacturers. It also serves medical and semiconductor manufacturers. It has partnered with companies in all three industries to help advance technologies key to FoF concepts. "A lot of our [nonaerospace] customers already are operating the factory of the future, so we had no choice



NORTHROP GRUMMAN

Northrop Grumman's Integrated Assembly Line—first of its kind in the industry—was conceived as optimized cells working together, versus a collection of proximate, disparate islands of automation.

but to follow suit," says President Tim Beatty.

Ultrasonic technology historically has been a fully manual process using gravity feed and manual controls, but in recent years Bullen has incorporated 3-D printing or additive manufacturing (AM), computer numerical controls, automation, data analysis and feedback loops into its custom-designed equipment, fixtures and tools. The company's proprietary feedback technology allows its ultrasonic machines to automatically adapt to customers' part variations, increasing precision and accuracy while doing a better job of controlling costs, according to Beatty.

These advances also allow Bullen to achieve small-batch manufacturing more efficiently. "We are able to seamlessly flow from a production part for life sciences to a prototype for semiconductors to a new design iteration for aerospace," he says. "We still have a significant way to go, but we are making good progress toward fulfilling our vision of Industry 4.0."

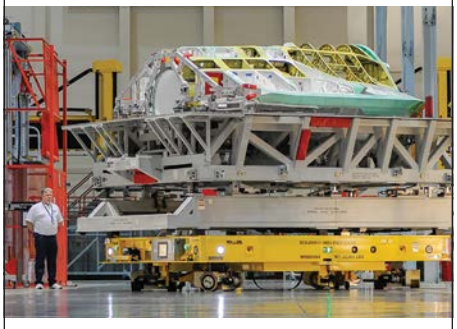
Rapid advances are being made in all the enabling technologies, not just AM, which gives Enrico Scharlock of Dassault Systemes' aerospace/defense business, an authority on advanced manufacturing, reason to believe many more companies will begin building the infrastructure required for the FoF.

Two of those technologies are robotics and automation, which Northrop Grumman is using on an integrated assembly line that builds the center fuselage of the F-35 fighter in Palmdale, California. "Both are integral to our vision of the factory of the future," says David Tracy, director of manufacturing for Northrop Grumman Aerospace Systems.

Unlike traditional stand-alone islands of automation, such as product-specific fixtures, the robots Northrop Grumman is using can be deployed quickly and at a fraction of the cost and can significantly improve throughput and cycle times, he notes. The advanced assembly line was inspired by automation systems used by U.S. motor vehicle manufacturers and was developed in partnership with KUKA Systems North America LLC.

More broadly, Northrop Grumman is incorporating advanced computing, advanced sensors, analytics and the IoT to not only provide first-time quality on production products but also integrate digital information from key automated machines and business systems to enable unparalleled shop floor visibility and proactive decisions throughout the factory.

In addition, the company is using data analytics to feed manufacturing information both upstream and downstream to proactively update and improve digital manufacturing instructions. It is extending the digital thread across the company's supplier base so that its partners will be fully aligned with what Tracy refers to as Northrop's Integrated Digital Enterprise, with modeling and simulation capabilities. This includes, among other things, the ability of suppliers to retain the integrity of digital information throughout the manufacturing process and product life cycle.



NORTHROP GRUMMAN

AIRBUS

NORTHROP GRUMMAN

Guided by GPS, Northrop Grumman's Integrated Assembly Line's (IAL) robotic vehicles (top) move center fuselage and tooling from station to station autonomously. An Airbus worker (center) uses a tool that can self-calibrate in real time. On the IAL (bottom), automated systems enable high-speed drilling of holes with a precision of 0.007 in.

Northrop is exploring the use of artificial intelligence in different applications as well, including the ability to make real-time decisions based on manufacturing data collected throughout the digital factory. "We believe we are on the cutting edge in the application of all of these technologies," Tracy says.

Another capability that will help enable the FoF is additive manufacturing, which Boeing is using extensively in production parts. The company has about 50,000 3-D-printed components flying on satellites and both commercial and military aircraft, but most of them are nonstructural in nature, says Leo Christodoulou, Boeing's enterprise additive manufacturing strategy leader. "We see AM as one of the critical elements of our digital factory of the future," he notes.

Engineers are continuing to develop tools and design principles to exploit how AM can add the greatest value. To establish AM's full potential, he notes, Boeing will need to train people to think in terms of designing parts specifically for AM, and just as importantly, devise a methodology for certifying the integrity of 3-D-printed parts. Christodoulou expects Boeing to have a totally integrated FoF in 5-10 years.

Manufacturing traditionally has been a process that turns raw materials into physical products. That is not necessarily true any longer. Rapid advances and the convergence in technologies are forcing aerospace manufacturers to rethink where value comes from and adapt to a dramatically changing landscape—one defined not so much by what can be manufactured as by *how* it can be made more efficiently to meet customer demands for quality, speed and cost, says Dassault Systemes' Tellier.

"The vision of the factory of the future is not exactly a new one, since it dates back at least 10 years," says Tellier. "Now all of the required capabilities are there, and we are seeing them rapidly mature. Companies that choose to not participate in this transformation are putting their long-term future at risk."

Gallery *See more examples of technologies for the aerospace factory of the future:* **AviationWeek.com/FoF**

IMAGINING THE FUTURE

Anthony L. Velocci, Jr. Wichita

Jeff Fisher, manager of the Virtual Reality Center at Wichita State University's National Institute for Aviation Research, uses Dassault Systemes software to demonstrate a realistic 3-D virtual interior of a Boeing 737 aircraft structural model.

As more aerospace manufacturers come to terms with what the production world of the future will look like, one of their biggest challenges almost certainly will be tied to critical workforce issues—preparing engineering teams and attracting enough people with the right technical skills to keep pace with technology's extremely rapid pace of advancement.

"As critical as all of the enabling technologies are to creating the connected factory, no less important are education and training," says Dassault Systemes' Michel Tellier, vice president for aerospace and defense. "Everyone from engineers to shop floor workers will need to be open-minded about the technology, understand his or her value in relationship to the end product, and be adaptable."

To facilitate such training, Dassault and Airbus have partnered with Wichita State University's (WSU) National Institute for Aviation Research (NIAR) on NIAR's Innovation Campus.

Dassault will operate a 3-D Experience Center that will provide the capability to go from innovation concept to a full experience of the idea to the realization of seeing that idea developed and produced. For its part, Airbus relocated its Wichita engineering center to a new building on the Innovation Campus, where it can take advantage of world-class laboratory facilities.

WSU expects to announce additional partners in coming months. Since NIAR operates on a nonprofit basis, it is able to integrate business, government and university resources cooperatively to advance aviation technology.

"Our first objective is to establish a pipeline of engineering talent for the future," says John O'Leary, vice president of Airbus Americas Engineering. The OEM expects to achieve this goal by engaging engineering students in the development and support of its products, as well as engaging the WSU Engineering Department through industry advisory boards and other targeted activities.

Airbus's Curtis Carson, head of manufacturing digitalization, notes that the company's workforce is "very much an integral part" of its efforts to create factories of the future (FoF). "The interaction of workers with the automated technology we want to implement will need to evolve with the smart tools they employ," he says.

Airbus already is conducting production trials as it works toward standing up its first fully functioning FoFs. "We are watching very closely to see how quickly the workforce adapts and learns," Carson says. "When they signal they do not want to give up the new tools on which they are training, we will know they are on board and that we are succeeding."

Airbus expects to collaborate with a handful of organizations on the Innovation Campus, including Dassault Systemes' 3-D Experience Center, scheduled to open in the second quarter of 2017. The laboratory is being configured and tested in NIAR's Robotics and Automation Lab at the National Center for Aviation Training. It will focus on enabling advanced product development and manufacturing of next-generation materials and technologies—including the ability to demonstrate production processes in a 3-D immersive environment and create a scalable FoF for learning and training.

"The whole idea is to demonstrate how to leverage the advanced technologies that will be integral to the factory of the future in a virtual world, before they are interconnected in the physical world," says Jeff Smith, director of Dassault Systemes' Aerospace and Defense Ideas Lab. "We believe our 3-D Experience Lab will take learning to a whole new level and prove very effective in helping create the workforce of the future."

WICHITA STATE UNIVERSITY

CHRISTIAN TIMMIG/LUFTWAFFE

On Alert

NATO using fighters to maintain recognized Baltic air picture

Tony Osborne **Amari Air Base, Estonia**

Compounding the biting cold of an Estonian winter is the tense atmosphere that surrounds Amari Air Base.

The former Russian navy fighter-bomber base is one of two sites housing NATO's Baltic Air Policing (BAP) detachments; the other is in Siauliai, Lithuania. The BAP's mission has steadily expanded since the emergence of a new wave of Russian aggression and the annexation of Crimea in 2014.

Currently, the fighters deployed by Germany and France to Amari and Siauliai, respectively, are there as a reassurance measure to the tiny Baltic states bordering Russia. Strategic placing of the combat aircraft in the area offers an element of deterrence to their increasingly unpredictable neighbor.

Since Sept. 1, Germany has stationed five Eurofighter EF2000s to police the skies of the Baltic States. Two aircraft are held on a constant 24-hr. alert, at a 15-min. readiness state.

Each is equipped with two live IRIS-T short-range air-to-air missiles, a pair of AIM-120 Amraams and a fully loaded gun, as well as chaff and flares for self-defense.

Scrambles are called when surveillance radars spot aircraft that are not squawking with their transponders, have not filed a flight plan and are not talking to local air traffic control. If an aircraft fails to meet just one of these three provisions, the fighters are launched, says detachment commander Lt. Col. Johannes Durand.

Crews detached here already have air-policing experience and will have been trained in the Quick Reaction Alert mission in Germany prior to deployment.

But unlike in Germany, where many scrambles are to reestablish communications with noncommunicative airliners or light aircraft, the mission in the Baltic States is about implementing NATO's directive for a "recognized air picture"—an awareness of every aircraft and its intention in the region.

Noncommunicative aircraft pose a significant threat to the region's growing commercial air traffic. But civil air traffic controllers do not have access to the surveillance radar capabilities of the military and so cannot always spot Russian aircraft on their screens. During an intercept, the air-policing fighters will squawk their transponders so civilian controllers can then spot roughly the position of the Russian aircraft.

Most aircraft violating the rules of the air are Russian-operated and fly between Russia and the Kaliningrad Oblast, Moscow's Baltic exclave.

"We have to be ready to scramble all day and all night and in all weather," says Durand.

The decision to launch is made by commanders at NATO's Combined Air Operations Center (CAOC) in Uedem, Germany. They determine which of the two detachments to send, based on their readiness and the geometry of the intercept.

Once airborne, the fighters will close in from behind and try to visually identify the aircraft and note its tail number. Still photographs will be taken and the entire sortie will be visually recorded on a digital video camera fitted in the cockpit. Pilots use night-vision goggles.

The crews try to maintain a 500-ft. separation, but this can be "hard to judge, depending on the aircraft type," says Capt. Martin Zielinski, one of the Eurofighter pilots deployed to Amari.

Five Eurofighters are currently deployed to Amari Air Base, where they will operate in all weather, including snow.

He describes an inherent curiosity about the BAP mission: "Once we are here, we can't wait to get into the sky and see those red stars," he said, refering to the tail markings on Russian jets.

The crews are able to conduct the intercepts, quietly using the Link 16 data link or by using the Eurofighter's radar, although at low-power settings in order to "deescalate" any tensions.

There are limitations on radar use, Durand explains. "Russia is not far away; we don't want to reveal all our tactics and capabilities," he says. "Sometimes we will intercept an aircraft [and find that] Swedish and Finnish fighters will already be there, but there is no coordination between us and them because of their neutral status."

Once the fighters return to base, maintainers turn the aircraft around within an hour so they can be put back on alert status.

Since Sept. 1, the Luftwaffe detachment has launched 28 "Alpha" scrambles to meet Russian aircraft, which have included fighters, transports and intelligence-gathering craft. The Estonian air force labels the passage of Russian aircraft as safety incidents because of their noncommunicative nature and impact on commercial air traffic.

The Estonian government had recorded 181 such incidents up to the time of Aviation Week's visit in December, compared with 295 in 2015. The Estonians had also noted 11 border violations, where aircraft had strayed into Estonian airspace, although many were minor incursions involving pilots likely taking navigational shortcuts and inadvertently crossing the airspace boundaries.

During Aviation Week's visit to Amari, the CAOC at Uedem scrambled its French Mirage 2000s to intercept a pair of Sukhoi Su-27s and the first Su-30SM fighter destined for the Russian navy's Baltic fleet. The German Eurofighters were held on the ground in case of additional Russian activity.

Germany started follow-on deployment at Amari in early in January, and the Royal Netherlands Air Force replaced the French Mirages based at Siauliai at the same time.

New Take on Old Connectivity Design

Startup broadband provider is big on ideas for network but short on details

John Croft Washington

More than a decade after the FAA proved the viability of an aircraft-based mesh network for broadband data distribution, Simi Valley, California-based Airborne Wireless Network (ABWN) has launched a commercial venture that could provide consumer broadband services in the continental U.S. and extra income for airlines within five years.

The big promises come from a company with a small footprint in the aviation business. ABWN lists five senior officials on its website, none of whom appear to have been involved in the FAA's earlier work with the technology or in the Airborne Internet Collaborative working group started by the now-retired Ralph Yost, the program's manager at the time.

The system, trademarked as the Infinitus Super Highway, would create a broadband communications pipeline moving data over long distances using ground stations and airliners as nodes and repeaters, forming a mesh network analogous to those proposed by SpaceX and others by using satellites.

Both networks aim to provide an alternative to ground-based cable and fiber-optic broadband technologies while allowing airlines to both tap into the data feed for their own cabin and cockpit purposes while earning revenue for passing data through to other users.

The FAA in the mid-2000s successfully demonstrated a similar concept, called Airborne Internet, in a series of flight tests with multiple aircraft and ground stations. But Yost says airlines at the time did not see a business case for deploying such a system.

ABWN is apparently convinced conditions are now ripe, however, as the company recently bought a 1998 patent titled "Broadband wireless communications system provided by commercial airlines" and began seeking investors.

The patent describes a system in which ground stations transmit broadband data to aircraft that are within line of sight. On the aircraft are "microwave radio frequency signal-relaying electronic devices" with multiple antennas that track both the ground stations and other equipped aircraft. Onboard electronics systems "receive, recondition and retransmit said broadband wireless signals for both directions at full duplex operation," according to the patent.

It is unclear how closely ABWN is planning to follow the patent. Jason de Mos, vice president of business development, was silent on the particulars of the Infinitus Super Highway, including the frequency band for cross-link between aircraft and uplink/downlink to the ground stations, the type and size of directional antennas, the business model for how the airlines install or make money on passing data, or the type and location of operating system that will control the mesh network. For satellite-based mesh networks, the logic that controls how satellites relay information to other satellites and ground stations is key to operational efficiency.

According to SEC documents, ABWN paid $40,000 for the patent and will continue to pay the patent's creator, Joseph Lai, 1.5% of its net cash revenues from the "marketing, sale, promotion, distribution and other exploitation" of the patent.

De Mos did say the company is planning a series of flight-test campaigns and supplemental type certifications (STC) for a large number of aircraft models, leading to a rollout of the service in 2-5 years. The first STC will be for the Boeing 757-200.

The company recently received an STC project number and plans to modify three former American Airlines 757-200s leased from Jet Midwest. The aircraft will be equipped with external top- and bottom-mounted directional antennas and internal electronics to conduct at least two proof-of-concept tests in February or March. The goal will be to seamlessly transmit broadband data from a ground station over long distances using the three aircraft as a communications daisy chain. De Mos says a broader slate of flight tests will occur 18 months after the first tests.

Similar airborne internet tests by the FAA and contractors a decade ago proved out the concept. Yost says airborne networking flight tests were performed with up to three aircraft using proof-of-concept systems of 90 Mbps on one system and only 25 kHz of aviation channel spectrum on another, proving that an aerial mesh network could provide broadband coverage. Both systems were operated simultaneously between three aircraft and multiple ground stations, and all tests were performed with standard networking protocols, says Yost.

For an operational system covering the U.S., the privately funded company envisions using approximately 200 ground stations. While the mesh network becomes increasingly reliable as more aircraft participate, the total number needed can be relatively small. From a typical cruise altitude of 40,000 ft., each aircraft will have a line-of-sight radio frequency range of 480 mi. De Mos says the company will most likely "tap into" an existing terrestrial network of an established telecommunications provider for the ground stations and backhaul networks (communications between ground stations).

Airborne Wireless Network plans to use this Boeing 757-200, now retired from American Airlines, and another 757-200 for proof-of-concept testing in February or March.

ROCKNROLLER92/YOUTUBE

New Directions

Politics, proliferation of budget airlines have Taiwanese carrier shifting strategy

Bradley Perrett Beijing

Keen to reduce Taiwan's economic reliance on China, President Tsai Ing-wen came to power in May 2016 with what she called the New Southward Policy. The island would seek trade and investment ties with Southeast and South Asia.

Taiwan's China Airlines finds that it must follow much the same path. Capture of the presidency by the Democratic Progressive Party, seen by Beijing as an obstacle to bringing Taiwan back under its control, has prompted China to limit mainland permission for travel to Taiwan. So China Airlines is also looking southward. Its excess capacity will head that way.

This is not the only factor behind the company's redirection. To the north, it sees signs of overcapacity on routes to Japan and South Korea, particularly because of the rise of budget airlines in those countries. And the arrival of Boeing 777-300ERs and Airbus A350-900s, replacing old and uneconomical widebody models, is improving profitability on long-haul routes and opening possibilities for more.

Setbacks in China and Northeast Asia are unwinding some of the airline's progress in 2011-15, when Beijing progressively allowed more of its citizens to visit Taiwan. Many Chinese are highly attracted by the island, which they see as part of their country. The carrier, rival EVA Airways, their subsidiaries and smaller Taiwanese carriers busily opened routes across the Taiwan Strait in that time.

Meanwhile, the North Asia market was growing, related in part to devaluation of the yen, which encouraged Taiwanese to visit Japan. But now profits there have come under pressure. "Competition from low-cost carriers on Japanese and Korean routes means there are now signs of oversupply in the market," China Airlines says.

So far, demand for cross-strait travel has not met company expectations. Obviously sending Taiwan a signal of its displeasure over the election result, the Chinese government is restricting the number of mainland tour groups it allows to travel there, though individual travelers seem to have no trouble in getting permits.

"Cross-strait political uncertainty as well as the Chinese government's restrictions on the number of visitors to Taiwan has slowed growth on cross-strait routes," says the airline in answer to Aviation Week's questions. "China Airlines will conduct a comprehensive review of cross-strait routes in the future and shift capacity as necessary . . . to reduce our losses and increase our revenues."

The carrier expects to consolidate services on its most profitable cross-strait routes, those to Beijing, Shanghai, Guangzhou and Xiamen. It will cut capacity by substituting 777-300ERs for 747-400s. Two years ago, the airline saw its then-fleet of 13 747s as a tool, unavailable to competitors, for maximizing its share on such routes. It thought at least four would be worth retaining for that purpose even as 777s arrived (*AW&ST* Feb. 16-March 1, 2015, p. 38).

China Airlines is also looking at varying service frequency or aircraft size for smaller Chinese markets. "As part of the capacity adjustments for China and Northeast Asia, excess capacity will be transferred to existing destinations in Southeast Asia," it says. The company also will consider new Southeast Asian routes.

The carrier built up its presence in some Chinese cities, especially in the south of the country, to prepare for a policy change in Beijing that Taiwanese carriers have long sought, one giving them permission to carry mainland passengers beyond Taiwan. Before the January 2016 election, the Chinese government began to do so, allowing passengers from Chongqing, Kunming and Nanchang to change flights in Taiwan and fly, for example, to the U.S. This was a small first step in changing the policy. There has been no second step.

Fleet renewal is driving changes in the long-haul business, as 747s and A340-300s are replaced by 10 777-300ERs, now all in service, and 14 A350-900s. The A350s are coming fast. The airline has received its first four in the past three months and expects the last to arrive in 2018. Exploiting the higher competitiveness of the Boeing and Airbus widebody models, the airline is initially increasing service density on routes that in some cases were probably not very profitable with 747s or A340s. The carrier will also evaluate the potential for new services. The arrival of A350s has allowed China Airlines to replace multi-leg services to Europe with direct flights.

In early 2015, the company was expected to order 50 narrowbody aircraft that year, some for subsidiary Mandarin Airlines and perhaps for Tigerair Taiwan, of which China Airlines is taking full control. But no such order has appeared, although six 737-800s were leased this year to replace old aircraft. The lease looked like a stopgap, necessary to tide the airline over until it was prepared to place the major order.

It is still not ready. "The capacity requirements of regional routes will be reviewed . . . before continuing with the fleet modernization selection process," the airline says.

With four of 14 A350-900s in service, China Airlines is replacing multi-leg services with direct flights.

H. GOUSSE/AIRBUS

Boiling Down

Even if Taiwan's TransAsia is revived, it will be shrunken

Bradley Perrett **Beijing and Sydney**

With a population of about 24 million people, Taiwan has had no shortage of airlines. Four months ago, eight carriers based on the island operated jet mainline aircraft. They included two budget airlines, each set up in 2014.

Now the local industry is undergoing a spasm of consolidation. First, one of the low-cost carriers was closed by its struggling owner, another airline. Then the owner folded. If the parent company is revived, a rival will own it, and it will be a smaller operation. One of the industry's two leading groups, meanwhile, is integrating subsidiaries more tightly.

That group, centered on China Airlines, is taking full control of a 90% subsidiary, budget carrier Tigerair Taiwan, and aims to integrate it into its operations and sales organization.

Low-cost competition for Taiwanese travelers is strong: Tigerair Taiwan counts more than 20 budget airlines from 10 countries serving the island. The budget market was even tougher before October, when a local competitor, V Air, ceased flying.

China Airlines has agreed to buy the 10% of the Tigerair Taiwan equity that it does not own from Singapore Airlines subsidiary Tigerair Holdings, the core company in the Tigerair chain. Once it is has 100% ownership, China Airlines will adjust Tigerair Taiwan's business. The acquisition is due to be completed by March 31.

"Changes will be concentrated in improving the load factor and aircraft utilization," the group says. To suit the Taiwanese market, use of travel agents will be increased. "Excess capacity will also be used for expanding the charter business to increase aircraft utilization and lower operating costs," the group adds. More indicative of the industry consolidation underway, Tigerair Taiwan will cooperate with China Airlines in operations and sales.

China Airlines already has a fully owned subsidiary carrier, Mandarin Airlines, which flies domestically and on some international routes. Its operations complement those of China Airlines. Similarly, the group intends for Tigerair to serve a distinct market, differentiated from China Airlines in terms of destinations, service and brand. As for Mandarin Airlines, "continued improvements are being sought through ongoing consolidation of group resources," the group says. Under current plans, that will not extend to a merger.

EVA Air, the core airline of the other main Taiwanese group, once intended to absorb affiliate Uni Air, in part to share resources. The obstacle was—and still is—the government's policy of sharing rights for services to mainland China between airlines. Losing the second airline would cut the group's entitlement. A spokesperson now says, "We currently do not have plans to merge EVA Air and Uni Air."

TransAsia Airways, at the time the third-largest Taiwanese airline, set up V Air in 2014. The move failed. Less than two months after the budget carrier ceased flying, TransAsia closed, having suffered persistent losses after two fatal crashes in two years. It is likely to be rather smaller if a revival attempt by fellow Taiwanese carrier Far Eastern Air Transport succeeds.

A key issue in the proposed takeover is that Taiwan's aviation agency is reassigning TransAsia's service rights to other airlines, which are due to begin operating them in February. China Airlines is temporarily flying some of TransAsia's routes.

Far Eastern says it will rehire at least 1,000 TransAsia employees if it can arrange a deal with creditor banks that will allow it to buy the business. But TransAsia had about 1,700 employees at the time of its demise, about 200 of whom have moved to other airlines. Far Eastern Chief Operating Officer Tseng Chin-chih says the company needs T$2 billion ($63 million) in capital, plus bank loans, to take over and restructure TransAsia.

TransAsia had valuable rights to serve mainland Chinese destinations, but Tseng says Far Eastern is most anxious to secure the failed airline's domestic routes, focusing strongly on Hualien, Kinmen and Penghu. This suggests a much-reduced operation, since none of those places has a large population; together they do not have even 500,000 people and could not fully use more than a fraction of the former airline's fleet for domestic connections. The routes could, however, attract many mainland Chinese travelers.

The Civil Aeronautics Administration of Taiwan says that, although it is aware of Far Eastern's attempted takeover, it is legally obliged to proceed with the reallocation of TransAsia's routes. That carrier had 27 routes to mainland China connecting 13 cities, including Shanghai, Chongqing, Hangzhou, Xiamen and Fuzhou, all large and strong markets that will attract the interest of China Airlines and EVA Airways.

But, Tseng says, "the strategy of Far Eastern will be different from [that of] China Airlines and EVA Air." It will focus on cities of the second and third tiers, he tells Central News Agency. "The markets will be clearly differentiated." He also says that Far Eastern hopes to secure all of TransAsia's routes.

P. PIGEYRE/AIRBUS

TransAsia and Far Eastern Fleets

	TransAsia*		Far Eastern
	In Service	On order	In Service
A330	4	4	
A320, A321	16	6	
MD-82, MD-83			8
ATR 72	8	2	

*As of Nov. 10, 2016 *Source: Aviation Week Intelligence Network fleet database*

TransAsia was Taiwan's third-largest airline before it closed in November.

'The Trail Has Been Blazed'

Raytheon CEO Tom Kennedy sat down in his office at the company's headquarters in Waltham, Massachusetts, with Aviation Week Editor-in-Chief Joe Anselmo and Managing Editor for Defense and Space Jen DiMascio.

FRAN BROPHY/ RAYTHEON

AW&ST: **Cyberdefense is becoming an important part of Raytheon's business.**

Kennedy: With the Internet of Things, cyber is pervasive in everything we do. The entire globe has become essentially a cybereconomy. The tip of the iceberg is really the information technology, but below the waterline there is a significant amount of concern about cybersecurity on the operational-technology side of the business—the factories that are automated with robotics, and how those are tied back to the original equipment manufacturers so that they can update and maintain them. That interface, unless it is secure, can be a concern. It goes all the way to something called vehicle-to-vehicle, where autonomous cars will be talking to each other. The big concern is that somebody gets into a car, plugs in their iPhone to listen to their favorite music, and somehow that iPhone was infected. And then it is spread vehicle to vehicle across all of those automobiles.

Raytheon's cybersecurity business, Forcepoint, has to compete against the commercial sector, the Ciscos and Symantecs. Has that been harder than you thought it would be?

No. Raytheon started off as a commercial electronics company 95 years ago. We have learned that when you are running a commercial company and a defense company, you have to separate the operations. But you do not have to separate the technology. So we believe what separates us from our competitors is that we have defense-grade solutions that are tried and true. We get attacked from all elements: nation-states, criminals, activists. We have protected ourselves against those and have created an unbelievable capability that we are taking to market. Forcepoint started off as a $250 million-a-year business in 2015 and it is already up to $600 million in revenue. It's growing in double digits and making a profit. What is very interesting to me is that the insider-threat capabilities we have provided to our government customers have now become an emerging market on the commercial side. We're very excited about that marketplace and tying it in with some of our data loss-prevention capabilities and offering the insider threat [competencies] combined with some behavioral analytics.

Is it really going that great?

I think it is. The reason we went into this is that the threat just mushroomed around 2007, almost overnight. So we reassessed our company in terms of technical gaps relative to cybersecurity, and since 2007 we have acquired 14 cybersecurity companies and integrated them into our business. But we did not have the market channels. We had just sold off the last big commercial part of the business, [business aircraft producer] Raytheon Aircraft. That's one of the main reasons we bought WebSense [in 2015, for $1.9 billion]. We broke out our cyberproducts group and combined that with WebSense, and that became Forcepoint. All of these products are used in Raytheon. We have an automated data site, so I can see in real time how these products and solutions we are offering in the commercial marketplace are operating in our [defense] environment.

Raytheon saw the cyber and international markets as avenues of growth after sequestration budget caps caused U.S. defense spending to decline. Is sequestration dead now that Republicans will control the White House and both houses of Congress?

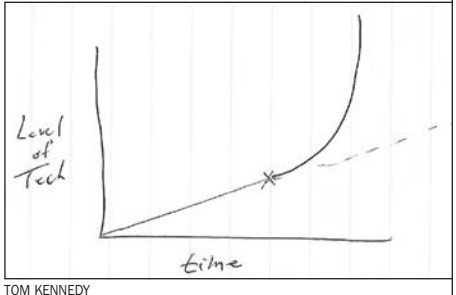
Sequestration is still the law. The new [Trump] administration has talked about revisiting it, so we'll see what happens. But Raytheon's strategy is to make sure we are a vibrant business despite sequestration. We put that into place back in 2014. At that time, 26% of our revenue was from the international marketplace. We moved that all the way up to 31% in 2015, and 44% of our backlog is international. Another area we worked heavily on was the new technologies we thought the Defense Department was going to be interested

in. We made some significant investments in hypersonics, high-energy lasers and undersea.

If you look at [the Pentagon's] Third Offset Strategy, we got a little bit ahead of the game. One of the [payoffs] was a recent contract from DARPA [the Defense Advanced Research Projects Agency] for the Hypersonic Airbreathing Weapon Concept program [to enable an effective and affordable air-launched hypersonic cruise missile]. We would not have won that if we hadn't altered our strategy to take the right focus on hypersonics.

There are so many new technologies that are becoming pervasive: automation, artificial intelligence, 3-D printing, autonomy. How much change are we going to see and how fast?

Give me a pen and a piece of paper and I'll draw you a graph [see illustration]. This is how we're looking at it. One axis is time, and the other is level of technology. We have been on a linear path,



TOM KENNEDY

but we believe we are getting pretty close to a big inflection point—an exponential curve. You just named most of the technologies. Artificial intelligence has been around for a lot of years. When I was getting my Ph.D. 30-plus years ago, I had somebody sitting next to me working on artificial intelligence.

What is different is that it is now being applied to real-life problems. Machine learning is an element of it, as is behavior analytics. The difference is that these things have been perfected to where they can be applied. Another example is nanotechnology. It is not going to create new elements on the periodic table, but it is going to change the behavior of those elements. There is some unbelievable stuff we are seeing. So we're preparing. Companies in the future that don't embrace technological change are not going to survive. With this inflection point, you are not going to be able to stumble, because there will be less time to catch up.

You've expressed concern that U.S. adversaries are catching up in closing the technological gap.

Think of the OODA loop: you observe, you orient, you decide, and then you act. [The U.S.] has been able to complete that loop faster than anybody else for years, based on our technology. We have also been able to slow down somebody else's OODA loop better than anybody else out there. But our adversaries are getting smarter on how to protect their OODA loops, so that we can't affect them as much. They're also figuring out ways to increase their speed—one of the things we are seeing is the use of hypersonics by some of these countries. We need to be able to slow them down and make sure we have the ability to degrade their observations, or be sure their observations are not as accurate as ours. We also need to orient ourselves faster. That's where things such as machine learning can come in.

Is the U.S. Air Force's T-X trainer competition a must-win for Raytheon and teammate Leonardo the way it is for some of your competitors?

We don't get into a competition to lose. When we go after something, they are all must-wins. This is serious for us. I think providing a solution that is low-risk in both schedule and cost is something that should be very attractive to the Air Force and the Defense Department. It is very safe, with two engines. Its cost of operation is low and has already been proven in several air forces. We are making some upgrades to meet the requirements, but essentially it is an off-the-shelf system.

It really depends on how the government emphasizes risk and cost versus cutting-edge, no?

How many brand-new products can the department take on? They have a lot on their plate. I think that having a solution that meets their needs and is time-certain and cost-certain is pretty attractive.

Raytheon's OCX [the Operational Control System for GPS] has experienced some major cost increases. What happened? Was it a case of the Pentagon and Raytheon not talking to each other? Was it a management issue?

It was a first-time issue. The first time defining what cybersecurity means, defining how we were going to test it to say we passed and getting that defined to the complexity of a GPS OCX system that has so many connections outside of its main command-and-control structure. It was not in the functional elements, it was in doing those in a 100% cybersecure way and then getting the definition on what 100% meant. This does use commercial hardware, and it turns out that anything you buy has open source software in it. So how do you go off and remedy that issue? That has never really been discussed before. It's all behind us now. We are off and running. But these are breakthrough technologies and ways of thinking about cybersecurity. The trail has been blazed, and we have developed some very unique processes and procedures that the department will be able to use on future programs. It definitely has made Raytheon's cybersecurity toolbox significantly stronger.

You talked about 31% of your sales last year being international. How is the market in Europe?

Europe has picked up significantly due to some of the concerns in Eastern Europe relative to some of the activities in Ukraine that have occurred in the last several years. We are also hearing that several NATO countries are looking to get back to 2% of GDP defense spending to support their commitments. That is creating additional demand, as they increase their readiness and then look for next-generation systems.

U.S. President-elect Donald Trump has threatened to punish American companies that offshore work to other countries. Could that affect Raytheon's international partnerships?

A majority of our work for the U.S., our allies and coalition partners is done in the United States. As a defense company, there are certain things you just can't do in other countries. We're not really affected by that, just due to the the business that we are in.

Power To Test

Unique NASA facility will expand understanding of electric propulsion

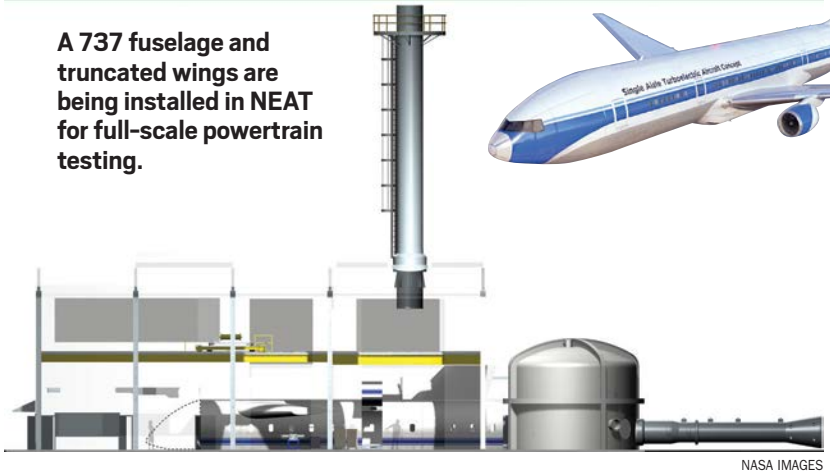
Graham Warwick Washington

Around the world, there are many facilities for testing aircraft propulsion systems based on gas-turbine engines. The technology is still advancing, but it is well understood. That is not the case for electric propulsion systems.

A wide range of electric drive concepts are being studied for future airliners, but before they can be flown in an aircraft they must be tested on the ground at large scale and high power, to safely wring out any system problems.

Aircraft electric propulsion systems must be lightweight, but operate at high power, high voltage and high altitude—a combination outside the experience of other industries.

Power and thermal management, fault-tolerant control, electromagnetic interference mitigation and unexpected system interactions all are aspects of electric propulsion that are new to aircraft and engine designers.



A 737 fuselage and truncated wings are being installed in NEAT for full-scale powertrain testing.

NASA IMAGES

To bridge the gap between laboratory and flight, NASA is creating a facility to enable full-scale, flight-weight electric powertrains for future single-aisle aircraft to be tested on the ground to technology readiness level 6.

The NASA Electric Aircraft Testbed (NEAT) will test complete drive systems at power levels up to 24 megawatts and bus voltages up to 4500 volts. NEAT is located at NASA Glenn Research Center's Plumb Brook Station, Ohio, in a former hypersonic tunnel and nuclear thermal rocket test facility.

Following refurbishment, NASA in September conducted its first low-power test in the facility, using a pair of off-the-shelf electric motors to emulate a General Electric CF34 turbofan. NEAT is now being outfitted with a Boeing 737-size electric powertrain to test the STARC-ABL—single-aisle turboelectric aircraft with aft boundary layer propulsion—a NASA concept for a near-term hybrid-electric airliner.

Testing of the STARC-ABL drive system is planned to begin in September 2017 at a low power of 0.5 megawatts, increasing to the full 2.6 megawatts—3,500 hp—in 2018. Other configurations will follow. "In the longer term, we plan to test powertrains for 150-passenger single aisles with different stages of electrification," says Rodger Dyson, hybrid gas-electric propulsion technical lead at NASA Glenn.

Plum Brook was selected because, as a former rocket test facility and Mach 7 wind tunnel, it had the power, cooling and cryogenic infrastructure required to support testing of high-power conventional and superconducting electric drives.

The initial test after completing refurbishment of the infrastructure was modest—a pair of 125-kW motors on a table—but exercised the NASA-developed control software as well as instrumentation, cooling and other services.

NASA is now installing a 737 fuselage and truncated wing inside the facility to provide the correct cabling and wiring lengths for a full-scale single-aisle electric powertrain. For the STARC-ABL, where generators on underwing turbofans drive a ducted fan in the tail, there is 32 ft. between the turbogenerators and 69 ft. from wing root to tailcone thruster.

For STARC-ABL testing, the setup includes enclosing the tail in a 20-ft. chamber that can be depressurized to test motors and inverters at full power at altitudes up to 50,000 ft., where electrical arcing at high voltage is an issue.

The rig is planned to be complete by August 2017. Testing will begin with off-the-shelf traction motors used in hybrid-electric ground vehicles. Produced by Parker, the 125-kW permanent-magnet motors are the lightest and smallest available, Dyson says. The motors are mounted in shaft-connected pairs: drive and load. Together, they simulate generators powering a ducted fan.

In STARC-ABL, the ducted fan in the tail ingests slow-moving boundary-layer airflow over the fuselage and reenergizes the wake, reducing drag. This reduces the turbofan size required for cruise, which in turn cuts weight and fuel burn. NASA's studies indicate a 7-12% fuel saving, with the complete propulsion system weighing 20% less despite the electric components, fan and duct.

In the NEAT rig, each turbofan is simulated by a pair of motors that are controlled to match the speed, torque and inertia curves of the gas-turbine engine. The tailcone thruster is simulated by pairs of motors controlled to mimic the dynamics of the ducted fan at different altitudes.

Tests will start with eight 250-kW motor pairs and provide 0.5 megawatts to the ducted fan, but by late 2018—when high-power flight-weight motors developed for NASA become available—the rig will generate 1.4 megawatts from each simulated turbofan to drive that tail thruster at full power.

NASA is funding five different efforts to develop 1-megawatt motors that are efficient and light enough for aviation use, says Dyson. "By 2018 we expect to have hardware that meets the specification." Superconducting motors and inverters are expected to become available in the 2019 time frame.

STARC-ABL is a series hybrid—power flowing from engine to generator to motor to fan. Next, NASA plans to test the parallel-hybrid architecture of Boeing's SUGAR Volt in NEAT. This has motors mounted on the turbofan shafts to augment thrust on takeoff and climb using batteries. Beyond that, Dyson says, NEAT could test the distributed turboelectric propulsion for ESAero's ECO-150 concept. This has wing-mounted turbogenerators driving arrays of ducted fans embedded in the wing.

Breaking Boundaries

Fan tests pave way for follow-on evaluations aimed at D8 and aft-propulsor configurations

Guy Norris Los Angeles

NASA says the first-ever large-scale wind-tunnel tests of a robust fan capable of operating in turbulent flow have proved successful, marking an early step on the path to a new generation of highly efficient airliners designed to take advantage of boundary layer ingestion (BLI).

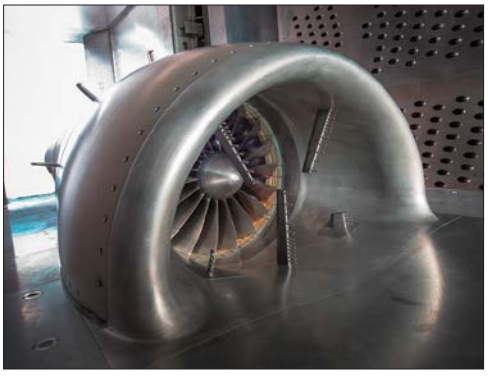
Researchers theorize that transport aircraft with embedded engines, or an aft-mounted propulsor, could see double-digit improvements in fuel-burn efficiency over tube-and-wing, podded engine designs. Up to 8% of the improvement could come just from ingesting the boundary layer. This is because the flow velocity into the fan from the boundary layer is slower than the free stream and—as there is no excess kinetic energy if the fan is ingesting the slower layer—less energy needs to be added to reach the same thrust.

However, the ability to ingest the boundary layer depends on development of a rugged fan. The unit must be optimized to operate not only efficiently under high propulsive loads in the distorted flow field of a partially buried inlet but also to withstand the punishing loads of such a turbulent environment. With this challenge in mind, engineers at the NASA Glenn Research Center are starting to review data from six weeks of testing just completed on a distortion-tolerant fan developed with the United Technologies Research Center.

"This has never been tried before, and it is a really complex experiment that's tried a lot of new things," says the NASA Advanced Air Transport Technology program manager, James Heidmann. To create the correct boundary layer conditions for the fan, NASA Glenn's 8 X 6-ft. transonic wind tunnel was modified to bring the floor flush with the recessed test inlet. This housed a 22-in.-dia. fan propelled by a universal propulsion simulator drive rig.

"One of the cool things was we added a false floor to create the boundary layer," Heidmann says. "Typically an engine is mounted [in the wind tunnel] so there is no boundary layer entering the inlet, but in this case we had this false floor extending upwind of the model."

A series of pins were placed ahead of the specially contoured test section to trip the boundary layer. Downstream, several feet ahead of the inlet, a series of suction systems were arranged spanwise across the floor of the tunnel to remove the turbulent flow. The six boundary-layer bleed units were used independently to control the thickness and character of the profile.



NASA

A large inlet lip radius and thick root fillets helped minimize flow distortion and control vortices into the test inlet.

"This particular geometry was designed for a blended-wing-body configuration with embedded engines, so we set up the wind tunnel to develop a boundary layer that was consistent with that," explains Heidmann. The experiment was focused on varying the boundary layer thickness and the operating point of the fan "to gain an understanding of fan efficiency and operability," he says.

To cope with the intense swirl and distortion caused by the inlet, the blades of the fan were thickened at the root compared to most conventional airfoils, had a reduced tip chord and were designed with a low incidence angle of 17 deg. Despite this optimization, test engineers knew the fan would encounter tip stall each time a blade passed through the lower hemisphere of its arc of travel and underwent major changes in loading. "There were parts in the operating range that required special care of the aerodynamic interaction with the fan, but there was a lot learned to improve the design," notes Heidmann.

By controlling boundary layer thickness, freestream velocity in the tunnel and fan speed, engineers simulated various flight conditions and steered clear of areas where fan stability could have been an issue. The fan system was tested for 17 runs over a freestream velocity range of Mach 0.55-0.78 and at fan speeds of 70-100%. The fan had a pressure ratio of 1:33 and was designed for 100%-control RPM at Mach 0.78. Rake arrays were set up to characterize the boundary layer, and vibration sensors monitored the operation of the fan.

Although the Glenn tunnel rig is static and focused mainly on testing cruise and steady state conditions, Heidmann says research using computational fluid dynamics (CFD) indicates boundary-layer ingesting inlets should perform well during maneuvering flight.

"We are finding from CFD that the BLI configurations are less sensitive to high angles of attack and sideslip," Heidmann points out. "One of the takeaways in BLI research is that a very thick boundary layer going into the engine really dominates the flow mechanics."

Although completion of NASA's full test report is not due until March, Heidmann says initial data looks "very favorable." Researchers are planning the next steps. "For other tests, there are lots of things we'd like to look at and other kinds of BLI." One of these is the Starc-ABL (single-aisle turboelectric aircraft with an aft boundary layer propulsor), a hybrid-powered airliner design with a tail-mounted fan. The design, which offers a 15% fuel-burn improvement over current aircraft, ingests about 45% of the boundary layer. Another BLI study possibility is the side-by-side engine installation of the D8 "double-bubble" concept being developed by Aurora Flight Sciences, NASA and the Massachusetts Institute of Technology.

"The aerodynamics of that are complex, so the intent is to have two adjacent fans with BLI. These are long-range plans, and this was the first try to design a fan for boundary layer ingestion. Based on what we learned, we think we could do an even better job next time. This design had some conservatism to make sure it would operate robustly," he adds.

ADVANCED PROPULSION

Detonation Drive

Rotating detonation engine agreement paves way to game-changing pressure-gain concepts

AEROJET ROCKETDYNE

Guy Norris Los Angeles

For over 70 years, jet engines have powered airplanes ever more safely and efficiently. But despite higher core temperatures and pressures, and the introduction of efficient propulsion concepts like the geared fan, conventional gas turbines may be running out of runway.

A fundamental change in the way a gas turbine combusts air and fuel in its core could open a path to a new era of jet engine development, however. Long pursued by propulsion researchers as a potential game-changing thermodynamic technology for gas turbines, the concept of pressure-gain combustion appears to be finally making headway.

After almost seven years of research and more than 700 hot test firings, a rotating detonation engine (RDE) pressure-gain concept conceived by Aerojet Rocketdyne is poised for a new phase of development aimed initially at ground-based applications but also one that could ultimately inject new life into jet engine development for aircraft.

Unlike current gas turbines in which air is compressed, mixed with fuel and combusted at a constant pressure, the air and fuel mixture in a pressure-gain engine is detonated in a wave that rapidly compresses the mixture and adds heat at a constant volume. Because detonations produce extremely high pressures, the unsteady constant volume combustion process creates pressure gain in the burner, offering potential improvements of more than 15% in thermal efficiency and fuel consumption.

But getting a detonation engine to deliver these efficiencies is extremely difficult. Despite at least two decades of experimentation with various pressure-gain combustion devices, researchers have yet to demonstrate a detonation engine that operates in a practical way, either as a means of augmenting current gas turbines or as a propulsion system in its own right.

Now, Aerojet Rocketdyne hopes to change this with the RDE. To be studied with the National Energy Technology Laboratory (NETL) of the U.S. Energy Department, the RDE is a simple combustion chamber contained in an annular ring that uses most of the compression for efficiency gains by allowing the detonation wave to propagate continuously around the curved edge of the chamber.

Under the $6.8 million RDE agreement, the company will work with a team of academic researchers from U.S. universities to mature a design that could replace conventional gas turbine burners in a combined cycle natural-gas-fueled powerplant. "We could get at least a 5% overall improvement in plant efficiency by using RDEs as combustors in the gas turbine," says Scott Claflin, director of Advanced Concepts for Aerojet Rocketdyne's Rocket Shop innovation group.

Upcoming tests will evaluate interaction of the unsteady RDE combustor with a turbine cascade.

The new phase of the agreement, which officially began with a kick-off meeting Nov. 30, will run through mid-2019, involving Purdue University, the University of Michigan, University of Alabama, University of Central Florida and Southwest Research Institute. Building on an earlier phase focused primarily on analytical modeling of an RDE combined-cycle powerplant, the new work will concentrate on "empirical hot-fire testing and computational fluid dynamics analysis of how the RDE will interface with the gas turbines in the powerplant," says Claflin. This phase will also include combining the combustor with a turbine cascade at Purdue, he adds.

Proving the ability of the unsteady combustor to interact efficiently with the turbine is crucial to the viability of the RDE, which differs from some alternative pressure-gain concepts such as tube-configured pulse detonation engines (PDE). These configurations fire intermittently because the fuel/air mixture needs to be renewed between detonation waves. Although PDEs have been developed and even were test-flown in 2008, Aerojet Rocketdyne selected the RDE as a more promising option because it is "a very elegant solution," says Claflin. "It has minimal moving parts and the combustion process is continuous, unlike a PDE, which has valves cycling on and off at high rates."

The RDE comprises an annular ring with nozzles at the inlet end that inject a mixture of fuel and air axially from a high-pressure plenum. The mixture is ignited once to begin the detonation process, which propagates circumferentially around the combustion chamber. The gas expands in azimuth and axially, while the exhaust and injection systems both operate axially. Because the detonation propagates in azimuth around the annular chamber, the kinetic energy of the inflow is reduced and the RDE uses most of the compression for gains in efficiency. "It is an unsteady process, but the axial flow is continuous, and we end up with very-high-power densities because of it," adds Claflin.

The RDE's inherent simplicity and robustness "lends itself to affordability," says Tyler Evans, vice president of Aerojet Rocketdyne's Rocket Shop Defense Advanced Programs. "We will look at the ability to cross-cut this technology into multiple applications because the fuel saving it offers is a big deal." For airborne applications, the RDE could be used for everything from rockets to advanced combustion chambers in turbine engines.

Beyond initial energy and utility uses, Aerojet Rocketdyne foresees commercial and military aerospace market openings for the RDE. "We will do business wherever it makes sense," says Evans, who adds that the NETL program will significantly help the company's push to reach a mature pressure-gain technology readiness level (TRL) from its current "TRL 2-3 area, to TRL 6." The work also adapts well to the Third Offset Strategy, a Defense Department initiative that seeks to identify the next generation of capabilities necessary to guarantee U.S. military superiority in the coming decades. "A lot of it is classified, but there is a lot of interest in the RDE," he adds.

Compact Power

A new take on rotary combustion engines promises high efficiency at low weight

Graham Warwick Washington

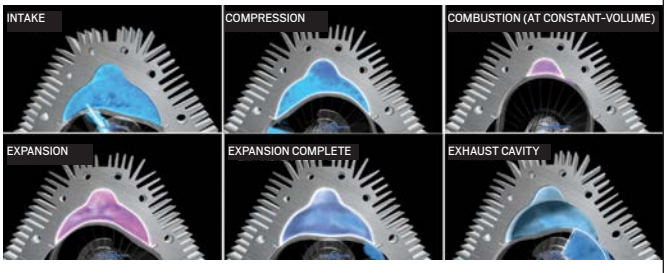
LIQUIDPISTON CONCEPTS

The initial X-Mini is a 70-cc rotary combustion engine weighing 4 lb. and producing 3-5 hp.

Military and other operators prefer using kerosene, rather than gasoline, across ground and air platforms, but lightweight, reliable heavy-fuel engines for unmanned aircraft systems (UAS) have proved challenging to develop.

LiquidPiston, a startup developing a novel powerplant that is smaller and lighter than piston diesel engines and more efficient than gasoline engines, has been boosted by winning Sikorsky's Entrepreneurial Challenge.

Developing multifuel rotary combustion engines based on its high-efficiency hybrid thermodynamic cycle (HEHC), the



The X-engine uses a high-efficiency hybrid thermodynamic cycle patented by LiquidPiston.

Bloomfield, Connecticut-based company has won $25,000 and the opportunity to explore applications for its X-engine on Sikorsky products.

"We are targeting our engine to be up to 10-15 times smaller and lighter than a piston diesel engine of similar power output and up to 2-3 times more efficient than gasoline engines, especially at part-power," says founder and CEO Alexander Shkolnik.

"This has obvious implications for aircraft or UAS, making them lighter or providing more power in the same weight, while extending range on a given amount of fuel," he says. "Our engine is heavy-fuel or multifuel capable, so it has broad application in military or civilian use, in aviation or beyond."

Already used to power UAS, Wankel rotary engines are simple and compact but pose design challenges in fueling, lubrication and combustion. "That is why they never took off, despite their simplicity," says Shkolnik.

"We took the Wankel and flipped it inside out. Instead of a triangular rotor inside an oval housing, we have an oval rotor in a triangular housing," he says. The result is a new cycle optimized for diesel, combining compression ignition, thorough combustion and overexpansion.

In a Wankel, apex seals on the triangular rotor move in and out at high speed during rotation. "The seals are impossible to lubricate, so they mix oil into the air, but 90% of the oil burns," says Shkolnik. "In our engines, the seals are on the stationary housing and easier to lubricate."

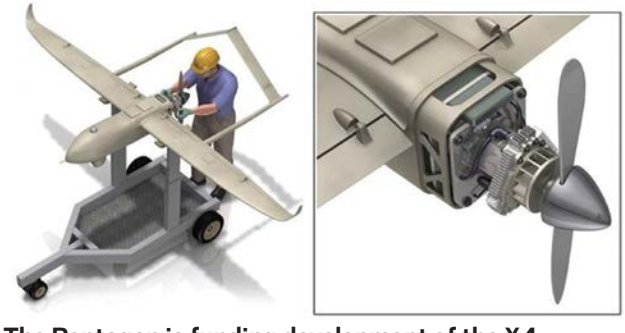
HEHC is a four-stroke cycle. The fuel/air mixture enters the X-engine through the rotor and is compressed and ignited. Constant-volume combustion increases efficiency. The combustion gases are then overexpanded before being exhausted through the rotor.

In a Wankel engine, inlet and exhaust ports are in the housing and are exposed as the rotor rotates. Compression and expansion volumes are the same. In HEHC, the expansion volume is greater, and overexpansion extracts more power from the engine.

LiquidPiston has been working on HEHC since 2004 and is now on its fifth generation of development engine. The X-Mini is a 70-cc spark-ignition engine that weighs 4 lb. and produces 3-5 hp. A demo engine has been tested in a go-kart, replacing a 6-hp piston engine weighing 40 lb.

At 3-5-hp, the X-Mini is suitable for powering smaller unmanned aircraft, generator sets and commercial products such as chainsaws and mopeds, says Shkolnik.

LiquidPiston has a Defense Advanced Research Projects Agency contract to further develop a 30-kW (40-hp) diesel X-engine for gensets and UAS. The 30-lb. X4 engine has compression ignition and three chambers.



The Pentagon is funding development of the X4, a 40-hp rotary engine weighing 30 lb.

Objectives include a specific power of 1.5 hp/lb. and a brake specific fuel consumption of 186 gram/kW/hr. (0.3 lb./hp/hr.)—better than a heavy-duty diesel truck engine and twice the fuel economy of a gasoline engine over a typical drive cycle.

Shkolnik expects the first X-engine to be ready "in a couple of years" after durability and certification testing. LiquidPiston's business plan is to license its technology to engine manufacturers and then provide services to design versions for specific applications, he says.

Last of the CRORs

Safran is about to test a counter-rotating open-rotor engine, despite waning appeal

Thierry Dubois Lyon, France

Safran Aircraft Engines' endeavor to demonstrate a counter-rotating open-rotor (CROR) engine is taking place amid a widespread faltering interest for the architecture, as the replacement of today's single-aisle commercial aircraft has been postponed repeatedly. In addition, the combination of technical challenges facing the CROR concept, the rise of the geared turbofan (GTF) and low fuel prices are slowing development.

In the late 2000s, two other major engine makers—GE Aviation and Rolls-Royce—also renewed interest in the concept. Rolls did plan to build a CROR demonstrator engine under the EU's Clean Sky 1 joint technology initiative. But it abandoned the CROR in favor of another demonstration program: a lean-burn, large three-stage turbofan.

On a next-generation single-aisle commercial aircraft, CRORs would cut fuel burn by a calculated 18% or so.

SAFRAN CONCEPT

GE's revitalized CROR research with NASA focused on the blades and was based on the same direct-drive architecture as for the original GE36 unducted fan (UDF) in the 1980s. GE subsequently provided conceptual engine data on a large CROR to Lockheed Martin for early design work on a hybrid-wing-body airlifter.

United Technologies Corp. has not returned to the CROR since flying the Pratt & Whitney/Allison 578-DX propfan in the 1980s. Pratt is only continuing low-level research at the United Technologies Research Center.

Pratt engineers instead are betting on evolutions of the GTF. Some former opponents of the GTF might even move to the PW1000G family's architecture. Rolls's UltraFan concept for 2025 uses a power gearbox between the fan and intermediate-pressure compressor. Under Clean Sky 2, Safran will build a geared turbofan sized for a future Airbus A320/Boeing 737 replacement.

All this is happening against a backdrop of relatively low fuel prices. Because of them, there is no longer an incentive to invest heavily and quickly in a radically new configuration. In 2012, oil prices were in the $90-100-per-barrel range, about twice today's price. At the time, a high-ranking EADS (now Airbus) executive in charge of innovation was considering the A320neo upgrade as an interim solution to coping with fuel costs. He was hinting that a replacement might enter service as early as 2022, but it is now unlikely this will occur before 2030.

Safran's CROR was to run on a ground testbed in 2015, but that step was postponed to this year and has now been put off until 2017. In 2010, flight testing on an Airbus A340-600 testbed was foreseen for 2015 but is now penciled in for 2020.

Despite the overall slowing of CROR development, Safran is adamant the concept must be explored as a means to reduce fuel burn drastically. Advances in modeling, in addition to progress in other areas such as materials, may enable the open-rotor idea to succeed where it failed 30 years ago.

In particular, today's understanding of aerodynamics will help solve the noise issue that contributed to killing the UDF and 578-DX. Trials in an Onera wind tunnel in 2013 validated a blade geometry that can meet Chapter 14 of Annex 16 of the International Civil Aviation Organization noise standards, Safran says.

A CROR engine would cut fuel consumption by about 18%, compared to the CFM Leap. "From the engine-maker's standpoint, we invest for the medium and long term, and fuel prices are still trending upward," Safran's CROR chief engineer, Olivier Jung, tells Aviation Week. A CROR engine is relevant for any regional or short-haul commercial aircraft in 2035, according to Jung.

Safran plans to test a CROR engine demonstrator in Istres, France, "in the coming months." Assembly of the demonstrator soon will be completed in Vernon, outside Paris, says Jung. It is part of the sustainable and green engine (SAGE) integrated technology demonstrator (ITD) project under Clean Sky. Asked about the continuing delay, Jung explains that the "breakthrough architecture" has caused engineers to cope with new difficulties, resulting in "delays in design and manufacturing."

Safran and its SAGE ITD partners —GKN Aerospace, Avio and Safran Nacelles—trust they can meet complex safety requirements. In the absence of a fan case, the blade is designed to prevent a blade-out event, which is considered unlikely as it is for a turboprop, says Jung. "Our aim is to demonstrate a high level of reliability, to avoid any significant impact on the airframe."

For the blades, Safran is using the same composite technology as in the Leap's fan.

Plans for an armored tail on a configuration that Airbus is studying suggest, however, that provisions must be made for a blade-out event.

Jung emphasizes the greater importance of airframe-engine integration. It will enable translating improved specific engine-level fuel consumption into reduced fuel burn at the aircraft level.

Whatever the fate of the idea, Safran is confident numerous "technology bricks" can be reused in other architectures.

—With Graham Warwick in Washington

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Jan. 24-26—VTOL Unmanned Aircraft Systems. Sheraton Wrigleyville Resort. Mesa, Arizona. See vtol.org/events/vtol-unmanned-aircraft-systems

Jan. 30-31—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

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

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

Feb. 14-18—Aero India 2017. Air Force Station Yelahanka. Bengaluru, India. See aeroindia.in/Default.aspx

Feb. 20-23—NDIA Gulf Coast Chapter International Air to Ground Symposium. Sandestin Golf & Beach Resort. Miramar Beach, Florida. See http://www.ndia.org/Pages/default.aspx

Feb. 22-23—Rotorcraft Handling Qualities Technical Meeting. University of Alabama-Huntsville Conference Center. Huntsville, Alabama. See vtol.org/events/rotorcraft-handling-qualities

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From the Editor

In my time as Aviation Week's editor-in-chief, nothing we have put forth so far has generated as much outrage as our naming Russian President Vladimir Putin Person of the Year in 2015. Though we prominently labeled Putin "notorious," a number of readers still missed the point that Person of the Year is not an honor, but our assessment of which individual has had the biggest impact—for better or worse—on the aerospace, defense and aviation industries in the year before.

"How can AvWeek, with all good conscience, call this devout Communist who has rekindled the Cold War the man of the year?" one reader complained. Some readers even cancelled their subscriptions. Luckily, the flood of comments also saw our intent: "AvWeek was gutsy, and probably right," one wrote. After all, Russia had invaded and annexed Ukraine's Crimea region, and Putin-backed rebels had shot down a Malaysia Airlines Boeing 777 with a Russian surface-to-air missile, killing 298 people.

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This year, Aviation Week has chosen as Persons of the Year the U.S. Defense Department's top three officials: Secretary Ashton Carter, Deputy Secretary Bob Work and acquisition chief Frank Kendall. Critics still complain that the Pentagon's vast acquisition system—which spends hundreds of billions of dollars every year—is a slow-moving bureaucratic nightmare. But Carter, Work and Kendall have made real progress toward fixing those problems, revving up the Pentagon's metabolism rate and reaching out for new technologies and non-traditional suppliers. As Michael Bruno and Lara Seligman detail (page 28), cost overruns in development programs have come down dramatically, the troubled F-35 program is on better footing and the new B-21 stealth bomber competition was meticulously crafted and survived a protest of its award to Northrop Grumman.

The Pentagon's Third Offset strategy has focused on rapidly tapping into new technologies to assure military dominance of the U.S. and its allies against new, asymmetric threats from nations such as China and Russia. Those threats mean the Pentagon and its contractors have to be much swifter in developing, fielding and continuously upgrading weapons platforms.

Raytheon CEO Tom Kennedy believes technology development is moving into a new era of exponential growth in areas such as artificial intelligence, autonomy, machine learning, 3-D printing and nanotechnology (page 48). Companies—and countries—that are not paying attention will swiftly be left behind.

The Carter-Work-Kendall team's work is not widely recognized outside of Washington defense circles, but the impact is undeniable. We call it a "quiet revolution."

President-elect Donald Trump's habit of tweeting about momentous geopolitical issues is worrisome, but his selection of retired Marine Gen. James Mattis to succeed Carter appears to be a sound choice. We encourage Mattis and his team to build on the progress of Carter, Work and Kendall.

So what do you think of our choice? If you agree with our selection of Carter, Kendall and Work, we'd like to hear. And if you think it was a bad choice, tell us why. Email us at awstletters@aviationweek.com. We'll publish the keenest of your responses.

Putting the spotlight on influential, and sometimes contentious, individuals is part of Aviation Week's effort to provide balanced, in-depth coverage of the aerospace, defense and aviation industries—and the technologies that are transforming them at a rapid pace. If you have thoughts, ideas or constructive criticisms to help shape our editorial coverage, email me at joe.anselmo@aviationweek.com

As for Putin, the former KGB agent certainly has lived up to our billing as influential. In recent months, Russia has helped the Syrian government bomb civilians, pushed aside President Barack Obama's inept foreign policy team and appears to have meddled in the U.S. presidential election.

We make mistakes at Aviation Week from time to time. And we thank readers for setting us straight. There are some editorial decisions that we have come to regret, but singling Putin out for his notoriety and impact is not one of them.

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