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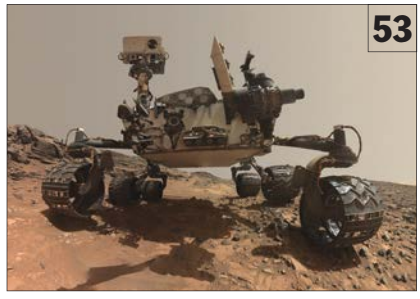
ON THE COVER

The F-35 Joint Strike Fighter has begun appearing at international air shows. Here, the STOVL variant of the Lightning II hovers above the airfield at Farnborough, England, in Mark Wagner's photo. Next up for the mammoth international fighter program are the complexities of logistics, maintenance and data sharing among allies (see page 29). Also in this issue: U.K. defense after the Brexit vote (page 26), biometric screening of airline passengers (page 55) and the future of Airbus's A380 (page 20). Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*



At the Farnborough Airshow, Aviation Week Editor-in-Chief Joe Anselmo (left) and Managing Editor-Commercial, Jens Flottau tour Embraer's first prototype E190-E2 passenger jet. The aircraft was flown to Farnborough from Brazil seven weeks after its first flight on May 23.

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

MLAT COVERAGE CONFUSION

"Hide and Seek" (*June 20-July 3, p. 13*) states: "Today multilateration (MLAT) coverage extends over most of North America and Europe, and parts of Australia, Brazil, China, India, New Zealand, South Africa, Taiwan and Thailand." This is true in a way, since areas of MLAT coverage comprise many spots across those countries, but it does not mean there is continuous coverage across these sites.


Inside Business Aviation

By William Garvey

COMMENTARY

Hide and Seek

That's 'S' as in 'Snoop'

The growing dissemination of Automatic Dependent Surveillance—Broadcast (ADS-B) technology has rekindled a longtime concern among business aircraft operators that their movements can be tracked in real time by anyone with the appropriate receiver.

In the U.S., coverage is mostly airport-centric. To cover the entire U.S. would require thousands of MLAT stations (ADS-B coverage takes hundreds of stations, each covering up to 250 mi.).

I am aware of one country with countrywide MLAT coverage: Austria. Its need started with Innsbruck, where instrument conditions reduced movements to 5 per hr. because radar coverage was impossible in the valleys leading to the airport. Rather than installing radars in the inhospitable and nearly inaccessible sites required to obtain the needed coverage, they opted for countrywide MLAT.
David Rost
MALVERNE, NEW YORK
(The reader is correct-Ed.)

Online, the "Hide and Seek" debate centered on right-to-privacy issues:

mike@traditions.com **queries:**
Why should aircraft operators have any higher right to privacy than automobile owners?

9402sierra **counters:**
It goes much deeper. Setting aside the security issues associated with the world knowing where potentially high-value targets of kidnap and coercion might be at any given time, it isn't clear that the world should know that Company A CEO's jet is making frequent trips to the location where potential merger target, Company B, is headquartered. With ADS-B data collected by private individuals and available on the internet, that fact cannot be hidden unless there is a means for masking the ID code at the transmitter.

edmckeogh@sympatico.ca **notes:**
A paradox. On the one hand we'd like to know where certain aircraft were when they went missing, yet we have certain people not wanting anyone to know where they are.

TJames **worries that:**
Parties will be able to use the data for initialization and tracking data for possibly current and future anti-aircraft weapons.

SUBSIDY BATTLE REDUX

On the matter of a likely trade dispute with the advent of new competitors in the single-aisle market (*July 4-17, p. 90*):

Talyn **says:**
Excellent article. Good points made that the UAC MS-21 and Comac C919 are essentially financed by the governments of Russia and China. When are Airbus and Embraer going to protest to the World Trade Organization (WTO)? Of course, Embraer has a history of being subsidized by the Brazilian government . . . and . . .

davidjpritchard **advises:**
The industry has "WTO aircraft subsidy fatigue." It's time for "can we all play together." All aircraft manufacturers get aircraft subsidies in one form or another. A four-country Large Civil Agreement (aka a next-generation 1992 EU U.S. Large Civil Aircraft Agreement) needs to be discussed among the EU, U.S., Canada and Brazil to allow all players the same level of government incentives to assist in launching new/updated aircraft programs.

tpg **notes:**
The "aviation game" is much like the medical field in the U.S.: trying to get a handle on cost vs. pricing is near impossible. Engines on the Airbus NEO, Bombardier C Series, UAC MS-21 and Embraer E2 are essentially the same, yet the financials are all over the place.

RAPTOR CG QUERY

In looking at the photograph of the F-22 and F-35 in formation that ac-

companies "Raptor Revisted" (*July 4-17, p. 75*), it struck me how far aft the wing the center of lift appears to be compared to the apparent center of gravity (CG) of the aircraft. Is there that much fuselage lift to move the overall center of lift forward closer to the CG?
Craig Price
ELLICOTT CITY, MARYLAND

FIGHTERS BATTLE FOR ORDERS

Observations and opinions online regarding "Fighter Flood" (*July 4-17, p. 68*) largely stressed lack of choice.

EngineeringRaconteur **posits:**
Technical aspects aside, the F-35, even the A, will not cost less than anything out there except maybe the F-22; anyone who claims otherwise is a salesman.

lesj **adds:**
I can't believe the F-35 is going to even be viable in a frontline situation in 30 years. . . . Its inherent weaknesses are already built in.

Sir leroy **reasons:**
It's not much of a battle considering the F-35 is 5th-gen stealthy and outclasses all competitors. . . . It is the only viable fighter today and one that, with upgrades, will still be relevant in the 2050s and beyond.

Correction: In "Fighter Flood" (*July 4-17, p. 68*), the numbers of Rafale aircraft on order and delivered in Europe were misstated. They are 180 and 138, respectively.

Who's Where

Steve Isakowitz

Edward L. Bolton

Darius Adamczyk

Claudio Onofrio

S. Willenbacher

Jean-Marc Germain

John P. Martin

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.*

Peter van der Horst has been appointed managing director of KLM UK Engineering Ltd., based in Norwich, England. The company specializes in maintenance for regional and narrowbody aircraft. Van der Horst has been vice president-line maintenance and held management and executive positions with Martinair.

The Aerospace Corp. has elected **Steve Isakowitz** (see photos) as president/CEO. As CEO, he will succeed Wanda Austin when she retires Oct. 1. Isakowitz has been Virgin Galactic president. In addition, Air Force Maj. Gen. (ret.) **Edward L. Bolton, Jr.,** has been named senior vice president-systems planning, engineering and quality, succeeding Rand Fisher, who has retired. Bolton had been FAA assistant administrator for NextGen.

Honeywell International has named **Darius Adamczyk** (see photo) to succeed CEO Dave Cote in March 2017. Adamczyk is president/chief operating officer and led the company's Scanning and Mobility business. He was CEO at Metrologic when Honeywell acquired it in 2008.

United Technologies Corp. has appointed **Vince Campisi** senior vice president-digital and chief information officer, responsible for UTC's global IT operations. He succeeds Nancy Davis, who will retire.

Bombardier Business Aircraft has named **Mike Fahey** vice president for Learjet 70 and 75 aircraft sales. Fahey has been vice president of sales for Learjet and preowned aircraft. **Peter Bromby** has been named regional vice president for preowned aircraft.

The *U.S. Air Force* has made a number of promotions: Gen. **Stephen W. Wilson,** promoted from lieutenant general, has been assigned as vice chief of staff U.S. Air Force. Wilson had been deputy commander, U.S. Strategic Command, Offutt AFB, Nebraska. Maj. Gen. **Thomas A. Bussiere** has been named commander Eighth Air Force Global Strike Command and joint functional-component commander for Global Strike, U.S. Strategic Command, Barksdale AFB, Louisiana. Maj. Gen. **James C. Dawkins, Jr.,** promoted from brigadier general, has been assigned as deputy director of Nuclear, Homeland Defense and Current Operations for the Joint Staff. Dawkins had been director of the National Security Council. Lt. Gen. **VeraLinn Jamieson,** promoted from major general, has been assigned as deputy chief of staff of Intelligence, Surveillance and Reconnaissance (ISR) at Air Force headquarters. She had been deputy commander of the Joint Functional Component Command for ISR, U.S. Strategic Command. Maj. Gen. **Steven L. Basham,** promoted from brigadier general, has been assigned as director-legislative liaison of the Office of the Secretary of the Air Force. Basham was deputy director.

The Space Foundation has named **Bryan J. DeBates** vice president-education. DeBates, who has been senior director, will oversee the development and implementation of foundation programs that support science, technology, engineering and mathematics education.

Global logistics company *Mallory Alexander,* headquartered in Memphis, Tennessee, has appointed **Claudio Onofrio** (see photo) vice president-global business development. His markets include the southern U.S. and southern Europe.

ServiceTec International Inc. has named **Laura Becker** vice president-business relations. Becker previously worked for systems integrators SITA and Rockwell Collins ARINC.

Malaysia Airlines Group has appointed **Peter Bellew** managing director/CEO of *Malaysia Airlines Berhad.* He succeeds Christoph Mueller.

Keith Green has joined *ASM* world route-development consultants to develop the company's interests in Africa. Green, who will be based in South Africa, headed network and fleet planning at South Africa Airways and Comair Ltd.

Seabury Group has rehired **David Fowkes** as managing director-Seabury Corporate Advisors, which provides restructuring services. Fowkes had worked with GA Telesis, Blue Air and at Bristow Group.

Bristow Helicopters Ltd. has promoted **Samantha Willenbacher** (see photo) to regional director-Americas. Royal Air Force Air Commo. (ret.) **Russell Torbet** will succeed her as director-U.K. civilian search and rescue for HM Coastguard.

FlightSafety International has promoted **Robert Standley** to manager of the company's learning center in Seattle.

Constellium has promoted **Jean-Marc Germain** (see photo) to CEO. He will succeed **Pierre Vareille,** who will retire as CEO but serve as an advisor to the board. The company produces specialty rolled and extruded aluminum products for aerospace and other markets.

OGSystems has hired **John Goolgasian** to lead the company's geospatial analytics efforts. He had been director of the Geoint Group in the National Geospatial-Intelligence Agency's Source Operations and Management Directorate.

Align Aerospace Holdings Inc. has appointed **Marc Invernizzi** general manager-Europe. Invernizzi had held management positions at Nitto EMEA, a Japanese polymer technology specialist.

Compass Logistics International North America has named **John P. Martin** (see photo) director. Martin had been vice president of Agility Logistics in Atlanta.

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First Take

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DEFENSE

Boeing's KC-46A tanker has successfully refueled a Boeing C-17 after installation of hydraulic pressure-relief valves in the telescoping boom to alleviate higher-than-expected axial loads that previously prevented refueling of the heavy airlifter.

Boeing has promised to create 2,000 jobs in the U.K. after it ordered nine P-8A maritime patrol aircraft and 50 AH-54E attack helicopters in Foreign Military Sales deals valued at £3 billion ($3.8 billion) and £1.78 billion, respectively. Boeing will build a £100 million training and support facility at RAF Lossiemouth, Scotland, the P-8 main operating base (page 26).

General Electric and Pratt & Whitney have each been awarded $1 billion in U.S. Air Force contracts to build and ground-test 45,000-lb.-thrust-class variable-cycle combat engines beginning in 2019 under the Adaptive Engine Transition Program (page 34).

China's Avic Y-20 four-turbofan airlifter has entered service. In the same weight class as Russia's Ilyushin

INTERNATIONAL AVIATION

Il-76, the Y-20 first few in 2013. Kawasaki has begun deliveries of the C-2 twin-turbofan airlifter to the Japan Air Self-Defense Force. First flown in 2010, the C-2 is in the same class as the Airbus A400M (page 32).

The Swedish air force has declared initial operating capability with the MBDA Meteor on its Saab JAS 39C/D Gripen fighters, making it the first air arm to field the European-developed, air-breathing, beyond-visual-range air-to-air missile.

A Qinetiq/Thales team is offering Textron Airland's Scorpion trainer/light-attack aircraft for the U.K.'s 15-year, £1.2 billion Air Support to Defense Operational Training program to provide adversary and electronic-warfare live flying training.

General Atomics Aeronautical Systems is preparing to fly its Improved

GENERAL ATOMICS AEROSPACE SYSTEMS

Avenger turbofan-powered Predator variant in September. Wingspan is extended by 10 ft. to 76 ft. The Avenger now has FAA experimental certification, allowing routine flights in national airspace.

COMMERCIAL AVIATION

Airbus is to cut production of the A380 to one a month in 2018, from 2.5, as it tries to keep the program alive in the face of poor orders and a dwindling backlog. CEO Fabrice Bregier says the lower rate will meet current demand, while giving Airbus two years to find new orders (page 20).

Moscow and Beijing have endorsed development of a Russian-Chinese widebody airliner in an equal partnership between United Aircraft Corp. and Comac. Preliminary design of the aircraft, broadly comparable with the Airbus A330 and for service in the mid-2020s, has been underway since 2014 (page 24).

At the Farnborough International Airshow on July 11-14, Airbus announced orders and commitments for 279 aircraft with a list-price value of $35 billion, and Boeing for 182 aircraft valued at $26.8 billion, business totals down significantly from recent major air shows. Deals included 269 A320 and 150 737-family aircraft.

China Aircraft Leasing Corp. and investor Friedmann Pacific have signed a preliminary order for 60 Comac ARJ21-700s to be operated by an Indonesian airline purchased by Friedmann Pacific. Swedish regional aircraft leasing company Rockton has signed a letter of intent for 10 firm and 10 option Mitsubishi MRJ90s.

Hungary's Wizz Air placed orders and options for up to 432 Pratt & Whitney PW1100G geared turbofans for its future fleet of Airbus A321neos at the Farnborough Airshow that also saw Pratt book commitments for PW1100Gs and V2500s to power 337 aircraft and rival CFM International for Leap 1s to power 581 airliners.

Boeing is studying a further stretch of the 777X twinjet. The 406-passenger 777-9X is scheduled to enter service in 2020 and the shorter, 355-seat -8X in 2022. Boeing is not specifying how large the extended version, dubbed the -10X, would be (page 22).

Sukhoi has started development of a stretched, 120-seat variant of the Superjet SSJ100, requiring a new wing with a higher aspect ratio. A "throttle push" to 18,000-lb. thrust on the Powerjet SaM146 engines will provide enough power, says Sukhoi.

ATR is proposing to first reengine the ATR 72, then develop a new 100-seater as the regional-turboprop

manufacturer tries to reconcile the differing views of its owners—Airbus favors reengining while Leonardo wants a bigger aircraft.

The first scheduled passenger services to Havana from the U.S. will be spread thinly. The Transportation Department tentatively awarded the 20 daily flights available to eight airlines: Alaska, American, Delta, Frontier, JetBlue, Southwest, Spirit and United.

Qatar Airways is buying 49% of Sardinian carrier Meridiana and a 10% stake in South American airlines group LATAM Airlines, continuing the Gulf carrier's strategy of acquiring minority holdings in large international airlines (page 25).

SPACE

The U.S. Navy's MUOS-5 mobile communications satellite is stuck in an intermediate orbit after an undisclosed anomaly halted its scheduled transfer to geosynchronous orbit following launch on June 24. The fifth Lockheed Martin-built MUOS is intended as an on-orbit spare.

ROTORCRAFT

TURKISH AEROSPACE INDUSTRIES

Turkish Aerospace Industries has cut metal for the first prototype of its 5-6 metric-ton (11,000-13,000-lb.) twin-engine indigenous utility helicopter. The program was formally launched in 2013, and the LHTEC T800-powered aircraft is not due to fly until 2018.

The first prototype Bell 525 super-medium helicopter crashed on July 6, killing both crewmembers. The fly-by-wire helicopter was on a test flight from Bell's Xworx facility in Arlington, Texas. Three aircraft had completed about 300 hr. of flight testing when the accident occurred.

PARTI LIBERAL QUEBEC

QUOTED

"There is not a cent of subsidy in this government intervention."

—QUEBEC PREMIER PHILIPPE COUILLARD,

asserting that a $1 billion investment for a 49% stake in Bombardier's C Series program complies with World Trade Organization rules.

Digital Extra *Read Editor-in-Chief Joe Anselmo's full interview with Philippe Couillard:* **AviationWeek.com/CouillardQA**

Avic/Russian Helicopters' Advanced Heavy Lifter (AHL) will be an almost entirely Chinese product, according to an agreement between Beijing and Moscow. The program will be managed by Avic. Russian Helicopters will develop certain subsystems on contract but not build them. The 38-metric-ton AHL is expected to be certified by 2025.

AWARDED

The Aviation Week Network has won Aerospace Media Awards for *Aviation Week & Space Technology*'s 100-year online archive, Amy Hillis's cover story on the Space-Based Infrared Satellite system and David Esler's work on international medevac operations in *Business & Commercial Aviation*.

Aviation Week Senior Editor Guy Norris has been made a fellow of the U.K.'s Royal Aeronautical Society. Based in Los Angeles, Norris has reported on aerospace for more than 30 years, joining Aviation Week in 2007.

16 YEARS AGO IN AVIATION WEEK

Airbus and Boeing announced $30 billion worth of airliner orders at the 2000 Farnborough Airshow, as Airbus officials said they would launch development of the "A3XX mega-transport"—later known as the A380—within six months (the launch came in December 2000). International Lease Finance Corp.'s signing of a commitment for five A3XXs "is ranked by Airbus's top executives as a milestone in the program's preparations," wrote Aviation Week's Pierre Sparaco. Airbus's bullish forecast saw demand for 1,200 500-plus-seat aircraft during the next 20 years, plus another 300 all-cargo derivatives. Boeing's analysts countered that demand would total less than 500 aircraft over two decades—and they appear to have been closer to the mark. Sixteen years later, Airbus has taken orders for 319 A380s, with 190 in operation.

FARNBOROUGH 2000

Archrivals Airbus, Boeing Ink $30 Billion in Orders

PIERRE SPARACO/FARNBOROUGH

The airline industry's robust growth is fulfilling the transport manufacturers' optimistic long-term strategy

Airbus Industrie's and Boeing's record backlog, which further expanded last week, signals the airline industry's robust growth rate and continuing confidence in the future.

Both aircraft manufacturers disclosed firm orders as well as letters of intent, options and purchasing rights for a total value of about $30 billion.

The Airbus consortium, which is scheduled to evolve soon into a stock company, says it has definite plans to launch the A3XX mega-transport in the next six months in the wake of commitments signed here by potential launch customers. "I am convinced that, by the end of the year, we will gather sufficient commitments to go ahead," Airbus Chief Executive Noel Forgeard claimed. He added that nine airlines have expressed intentions to order a combined 52 aircraft.

Emirates, Air France and the International Lease Finance Corp. (ILFC) confirmed plans here to order the A3XX-100, including the aircraft's all-cargo version, as soon as the program obtains a go-ahead.

Dubai-based Emirates, which was the first airline to send Airbus a nonbinding "letter of interest" in the ultra-high-capacity transport, signed a "firm commitment" here and placed an undisclosed deposit covering five passenger aircraft and two all-cargo A3XX-100Fs. Although the first A3XX is scheduled to be delivered in October 2005, Emirates would receive its first aircraft in February 2006 while its freighters would enter service in 2006.

Emirates' A3XXs are expected to be operated in a three-class, 579-seat cabin configuration, up from the basic aircraft's 555-seat basic arrangement. The first A3XX freighter would join Emirates' fleet in 2008.

Air France, which earlier this year had not expressed a short-term need for A3XX-category aircraft, signed a letter covering 10 aircraft and an additional four options. Service entry date would be 2006 and the 14th aircraft would be delivered to the French flag carrier in 2009.

Air France's A3XXs are scheduled to be operated between Paris and New York, Montreal, Miami, Los Angeles and Tokyo. Chairman/CEO Jean-Cyril Spinetta said. Air France currently does not intend to order the aircraft's all-cargo version, he added.

ILFC's commitment to order five A3XXs, also signed here, is ranked by Airbus' top executives as a milestone in the program's preparation. "The A3XX is a natural addition to our portfolio and a very measured increase in our wide-body aircraft commitment," ILFC Chief Executive Officer Steven Udvar-Hazy pointed out. By 2005, 30-40 city-pairs will reach saturation and require 500-plus-seat aircraft, he added.

"We look at the manufacturers' [contrasting] market forecasts with some degree of caution, and we think that the truth is in the middle," Udvar-Hazy said. He was referring to Airbus' optimistic predictions and Boeing's significantly more conservative analysis of the demand for 500-plus-seat aircraft. "Pricing of the A3XX is competitive with the 747's, and its direct operating costs will be 12-15% lower," Udvar-Hazy said. "We are also evaluating the Boeing [747X] alternative," he added.

According to Airbus, major carriers in the next 20 years will secure orders for 1,200 500-plus-seat aircraft and 300 additional all-cargo derivatives. But Boeing's analysts claim that the demand will be for fewer than 500 of the big aircraft.

"Boeing and Airbus forecast similar air travel growth rates over the next 20 years. But it's how airlines accommodate future growth that differentiates the future fleet mix forecast," Randolph S. Baseler noted. He is Boeing Commercial Airplanes vice president for marketing. He added that in an increasingly fragmented market, demg-

Nine airlines have indicated an intention to order a total of 32 555-seat A3XX mega-transports, according to Airbus. This A3XX rendering is in Air France livery.

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By Michael Bruno

Senior Business Editor
Michael Bruno blogs at:
AviationWeek.com/ares
michael.bruno@aviationweek.com

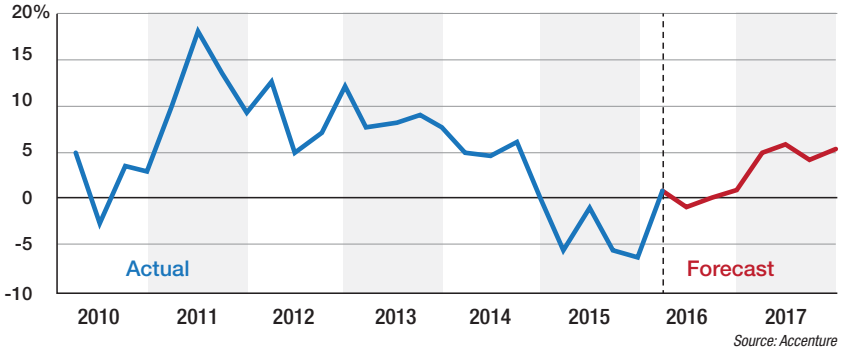
COMMENTARY

Throttling Back

Trends bode ill for aerospace manufacturing

When it comes to aerospace business activity, is it straight and level, or storm clouds ahead? Either way, halfway through 2016, one thing is sure: Analysts and consultants say the rip-roaring sentiment of recent years will be absent the rest of the year.

Global Commercial Aerospace Index Performance
(quarterly year-over-year percent change)



Source: Accenture

According to reports released to Aviation Week ahead of the Farnborough Airshow, observers say the sector is easing off the proverbial throttle in business activity. Those sentiments could be confirmed in coming weeks as public companies report their latest quarterly or midyear financial results.

Underpinning lower expectations are: Britain's "Brexit" vote to leave the EU, pending U.S. elections, oil prices finding a new and higher price floor, a strengthening U.S. dollar and forecasts of slowing gross domestic product results from leading national economies.

"While many are bullish on the aerospace market, there are immediate headwinds that are tempering gains made over the past few years," says John Schmidt, global managing director of Accenture's A&D practice.

Beyond macroeconomic and geopolitical factors, Schmidt's shop also sees a flattening of the business cycle—which, for better or worse, confirms an argument made by major OEMs like Airbus. They have claimed the historical up-and-down nature of aerospace business is history. Accenture concurs in the abstract, saying commercial aerospace growth year to year has slowed, with second-quarter comparisons expected to be down 0.3% when the final data are calculated.

Accenture believes commercial aerospace demand will remain relatively flat for 2016 and "slightly" pick up momentum in 2017, driven by the Asia-Pacific and North American markets (see graph).

Still, financial analysts at RBC Capital Markets note in their Airline Scorecard that commercial passenger traffic, load factors and share prices have all dropped recently. These bode ill for aerospace manufacturing in the near term. "We've now had sub-5% traffic growth for two consecutive months—and this is before the impact of Brexit, any response to the [June] terror attack on Istanbul [Ataturk] Airport, and less ticket-price stimulus, given the rally in crude," RBC says. "The continued slippage in load factors would also suggest that airline capacity growth remains higher than underlying demand, and . . . some airlines [are] trimming their capacity growth plans."

According to RBC, manufacturers rely on 4.5-5% traffic and capacity growth through this decade to justify their planned best-case build-rate increases. If traffic falls to 4%, there could be a surplus of more than 1,000 aircraft. "Airlines can address the oversupply by stepping up retirements or deferring new aircraft deliveries," RBC says, "and that calculus could be very different in a $50 [per-barrel oil environment], post-Brexit situation than what we saw in prior periods of softer airline traffic demand."

Yet not everyone thinks the airliner backlog is under serious threat. While orders for new, large commercial aircraft have slowed during the first half of 2016, the airframers' historic backlogs remain solid, consulting group Deloitte notes. "There is no bubble," says A&D Vice Chairman Tom Captain.

A Deloitte study examined the credit agency ratings of 215 airlines that ordered everything from the Bombardier C Series to the Airbus A380. The conclusion: Even a "severe" recession would lead to no more than 11.6% of the backlog becoming at risk of deferral or cancellation. Even so, there would still be the equivalent of 8.4 years' worth of work. By comparison, during the global financial crisis of 2008-09, just 5.4% of the same backlog evaporated.

Still, Deloitte's study does not look at regional jets, and it does not scrutinize individual backlogs by OEMs. It also does not consider the business cases of the competing airlines. But it does offer other clues. For example, backlog from the Asia-Pacific region, where Airbus has outsold Boeing, is the shakiest, with 24% of orders classified as "vulnerable." By contrast, just 5.5% of the North American backlog, and virtually none from the Middle East, is rated "vulnerable." Furthermore, leasing companies account for less than one-quarter of the backlog, but just 6.3% of their orders are rated "vulnerable," while 27.3% of orders from low-cost carriers are considered at risk.

Regardless, Captain says Airbus and Boeing plans to ramp up production should not be a worry. "There's a fairly even match between the number of seats being pushed into capacity versus what the demand is for air travel," he says.

By Richard Aboulafia

Contributing columnist Richard Aboulafia is vice president of analysis at Teal Group. He is based in Washington.

COMMENTARY

The Iran Illusion

Why Airbus and Boeing may be chasing fool's gold

SEAN D'SILVA/WIKIMEDIA

Unless the Farnborough Airshow sees a cloudburst of unanticipated orders, the large jetliner industry will have its first year since 2009 with a book-to-bill ratio lower than 1-1. Through June, there were fewer than 450 net Airbus and Boeing orders. For an industry addicted to ever-higher record production rates and an average book-to-bill ratio of 1.8-1 in 2010-15, this is a troubling development, particularly with global political and economic uncertainty looming in the background.

In this context, two large Iranian jetliner orders would be very welcome news. In January, Airbus announced an agreement for Iran to purchase 118 jets; in June, Boeing concluded a deal to sell it about the same number. But there are strong reasons to doubt that Iran will ride to the industry's rescue this year—or anytime soon.

Consider Iran's aviation industry in a broader regional context. Since 1990, Middle East traffic has grown from 30.8 billion revenue passenger miles to more than 400 billion today, according to *The Airline Monitor*. The total Middle East commercial fleet expanded to over 1,600 today from 242 jets in 1990.

But Iran is a backwater here. Once its fleet was the most important in the region. Iran Air famously even ordered the Concorde. Despite strong population growth though, Iranian carriers transport a tiny fraction of this traffic. The country has about 150 operational transports, more than one-third of which are smaller regional types.

Iran's international traffic is increasingly routed through the nearby Gulf state carriers. Etihad Airways, Qatar Airways and most of all Emirates have taken the bulk of the region's fleet and traffic growth. As state-run or state-controlled businesses, Iranian airlines simply do not have the service, global reach or brands needed to compete with the Gulf carriers. Iran's civil aviation industry also has an appalling safety record.

Financing the new Iranian jets is a major problem as well. While the post-sanctions windfall of released assets will help, there are many competing priorities. Low oil prices mean the government is running a serious deficit. And third-party financiers—essential to the jetliner business everywhere else—may decide that funding jets for Iran means unacceptable risks. Imagine trying to repossess a jet in Iran, which is not a Capetown Convention signatory.

Iran's jetliner requirements could be real, but only if Tehran also agreed to reform its miserable state-owned economy, create private-sector airlines and adhere to international finance norms. There are no plans to do anything like this. So it is likely most Iranian international traffic will continue to fly on other countries' airlines.

Despite all this uncertainty, the two jetliner primes are eager to tout these orders as firm, particularly since they include current-generation jetliners that are most profitable but most vulnerable to production cuts. These include Boeing 777s and 737NGs and Airbus A330s. For Airbus and Boeing, the possible orders offer a strong message to investors who are concerned the industry has peaked.

But more than this, the order announcements give everyone else involved exactly what they want. The Iranian government wants to leverage commercial opportunities for Western companies as a way of gaining negotiating power, both in the nuclear agreement and subsequent negotiations. At last year's Paris Air Show, Abbas Akhoundi, Iran's transport minister, said the country needs more than 400 jets worth $20 billion. This has since increased to "400-500" jets.

Therefore, politicians in the West who are in favor of the nuclear deal get what they want by taking credit for these commercial sales, linked as they are to the nuclear agreement. A U.S. State Department spokesman said the agreement allows "civil aviation companies, including American companies, to pursue legitimate commerce with Iran," which is good "for both the economy and for public safety."

Republicans eager to criticize the Obama administration get what they want, too. Right after last month's sale, Reps. Jeb Hensarling (R-Texas) and Peter Roskam (R-Ill.) wrote in a letter to Boeing: "American companies should not be complicit in weaponizing the Iranian Regime."

Finally, consider presidential candidate Donald Trump's position on these orders. In February, after the Airbus order announcement, he told a CNN town hall meeting: "They bought 118 Airbus planes, not Boeing planes. They're spending all of their money in Europe. . . It's so unfair and it's so incompetent. . . . We're handing over $150 billion. We get nothing." But in June, after the Boeing order announcement, his campaign issued a press release stating: "The world's largest state sponsor of terror would not have been allowed to enter into these negotiations with Boeing without Clinton's disastrous Iran Nuclear Deal."

Clearly, everyone gets what they want from these illusory Iranian jetliner orders. Even when they have no clue what that is.

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COMMENTARY

The Doctor Is In

The making of a 24/7 'everywhere' ER

Of all the participants converging on Rio de Janeiro for the the Summer Olympics, the winged insect *Aedes aegypti* has the special attention of Paulo Alves and his team headquartered in Phoenix.

MEDAIRE PHOTOS

The global medical director for Aviation for MedAire, cardiologist Dr. Alves is busy fielding questions from travelers regarding the mosquito most frequently associated with transmitting the Zika virus so concerning to athletes and others.

To protect oneself, he advises remaining indoors if practicable, and when going out wearing long-sleeve shirts and applying a DEET-based repellent. Alternately, avoid areas where Zika is endemic, a course of action likely to be followed by some MedAire clients, who include business aircraft operators, yacht owners and airlines.

MedAire was created, in part, to help customers recognize a health risk in advance of traveling and then work to mitigate or avoid it. Its services expanded early to include addressing medical emergencies in flight and later grew to address personal security risks around the world.

Founded in 1985, MedAire was the brainchild of Joan Sullivan Garrett (see photo, right). A critical-care registered flight nurse with the Samaritan Health System, her experience helping patients in desert areas convinced her of the need for providing emergency medical care to people in remote locations.

Initially, she provided training to business aviation pilots and flight attendants in handling inflight illness and injury. Then in 1987, with a $22,500 investment by Samaritan, she created MedLink, now a key feature of MedAire. It is a communications link whereby flight crews can call during an inflight medical situation and be immediately connected with an emergency room (ER) doctor for advice (see photo above).

According to MedAire, 80-90% of the events are resolved in flight, but when conditions warrant, the doctor may advise the flight crew to land as soon as possible—something business aircraft can more easily do than an airliner. By the time the aircraft touches down, MedAire staff will have alerted the fixed base operation or airline and local medical providers of the circumstances.

Soon after MedLink went live, a passenger-in-distress call came in from an American Trans Air flight that was over the mid-Atlantic at the time. ER Dr. Robert Baron fielded the call, diagnosed a heart attack was in progress and recommended that the airliner divert. It did, and the passenger survived.

The number of inflight calls grew steadily as more business flight departments and airlines signed on. According to CEO Bill Dolny, MedAire receives more than 7,000 inflight medical calls a month, most from airlines due to their higher passenger count.

Customer aircraft are equipped with MedAire-created emergency kits. Indeed, it was in part due to Garrett's testimony that the FAA now requires aircraft weighing more than 7,500 lb. and crewed by at least one flight attendant to be equipped with an approved automated external defibrillator and enhanced emergency medical kit.

Since medical emergencies can be the direct result of an unexpected event while traveling—anything from a car accident to a passenger mugging or assaults on crews—MedAire expanded its coverage to include security assessments, alerts and protection globally. Business jets and yachts are "flashy things" that can draw unwelcome attention in parts of the world, Dolny notes.

He was sought out by a customer at the National Business Aviation Association (NBAA) convention last November. The European charter operator's crew had been attending a meeting near their Beirut hotel just days earlier when a pair of suicide bombers exploded backpacks nearby, killing 43 people and injuring 200. The operator contacted MedAire for help. Within an hour, company security personnel in Dubai briefed the pilots on the evolving situation and recommended a safe route to the airport. The charter crew made it home without incident, and the operator wanted to say "thanks."

Today, roughly half of MedAire's 200 interactions with business aviation customers each month involve security matters, typically pre-trip briefings about destinations.

The company regularly updates the health and security risks in the 250 most frequented sites worldwide.

In 2008, MedAire became a part of International SOS, an umbrella organization with over 250 company affiliates that provide medical assistance, security, evacuation, travel and consulting services and that operates 27 assistance centers worldwide.

Meanwhile, Nurse Garrett continues as MedAire's chairman, celebrated for turning a good idea into a global reality. She has been a board member of both the NBAA and Flight Safety Foundation and has received numerous prestigious awards for her work. Beyond that, she's a truly lovely person. Hers is a gold medal career.

Air Canada's award-winning fleet finds success with ExxonMobil

In the highly competitive airline industry, the key to any successful, long-term business partnership is trust.

And for nearly 15 years, Air Canada, a member of the Star Alliance, has trusted ExxonMobil as its primary lubricant supplier.

According to Oleksii Lyeshchyner, power plant engineer at Air Canada, there are a few reasons why this partnership with ExxonMobil makes business sense.

"ExxonMobil has consistently delivered the right lubricant solutions, expertise and ongoing support we've needed to help optimize the performance of our fleet," Lyeshchyner said. "The ExxonMobil team also challenges us to consider new approaches that can help us reach our performance goals."

As a leader in aviation lubricant technology, ExxonMobil constantly looks for ways to help Air Canada optimize the performance of its fleet, which today serves 200 airports and transports more than 41 million passengers annually.

That's why, when ExxonMobil recommended Mobil Jet™ Oil 387 — its most advanced, synthetic jet engine High Performance Capability (HPC) oil — Air Canada pursued an aggressive testing program with the oil.

Over the past four years, Air Canada has worked side by side with ExxonMobil's aviation experts in conducting commercial flight tests with Mobil Jet Oil 387 on a number of leading engine technologies, including GE Aviation's CF6 and CF34 engines, and Pratt & Whitney's PW4000 models.

More than 60,000 hours of extensive flight tests on both the CF6 and CF34 engines showed that Mobil Jet Oil 387 jet engine oil was able to deliver outstanding engine cleanliness while also providing exceptional seal compatibility.

> "The ExxonMobil team also challenges us to consider new approaches that can help us reach our performance goals."
>
> — Oleksii Lyeshchyner, power plant engineer at Air Canada

"I'd say that within the next 10 to 15 years, we will see Mobil Jet Oil 387 become the main jet turbine oil for our industry," Lyeshchyner said.

Based on its favorable results so far, Air Canada is evaluating its use fleetwide.

"Our maintenance and engineering teams have been impressed with Mobil Jet Oil 387's performance thus far," said Joshua Vanderveen, manager of propulsion engineering at Air Canada.

Looking ahead, Vanderveen is confident that Mobil Jet Oil 387 — and ExxonMobil's technical expertise — will continue to play a pivotal role in helping Air Canada accomplish its maintenance objectives.

By minimizing engine repair and maintenance costs, Mobil Jet Oil 387 helps keep more flights on track, which helps Air Canada deliver on its mission to provide customers with a reliable experience.

ExxonMobil
Energy lives here™

By Jens Flottau

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COMMENTARY

Voice of the Customer

Airlines define their MOM requirements in a joint Aviation Week/Bank of America Merrill Lynch study

Boeing believes there is a big market for a new aircraft in the space between the current Boeing-Airbus narrow body families and the smallest widebodies. What has not been determined is the size and performance characteristics of that so-called middle-of-the-market (MOM) aircraft.

Now, a joint survey of airlines and air cargo carriers by Bank of America Merrill Lynch and Aviation Week/Penton Research provides some clues about what airlines want in a new aircraft, be it from Boeing, Airbus or a new player in that segment. Some of the results are surprising and show how technologically challenging such a project would be for a manufacturer launching an aircraft in the category.

First surprise: Airlines, traditionally conservative when it comes to innovations that are challenging to much of their operational status quo, seem to be prepared to reintroduce widebodies into medium-haul flying. Sixty percent of the carriers participating in the survey would consider ordering a small widebody, provided it fits into existing airport gate infrastructure.

The limitation at many airports is wingspan: A new aircraft cannot be much wider than an Airbus A320 or Boeing 737 if it is to use narrowbody gates. And wingspan is defined in part by the range requirement, which leads to the next challenge: Of the airlines interested in buying a MOM jet, 22% would need a range of 4,000-5,000 nm, 24% 3,000-3,999-nm range and another 23% only 2,000-2,999 nm.

That wide spread of range requirements is a major issue for aircraft designers. A significant number of airlines merely want more passenger capacity; others want range, and some want both.

Also, almost half of the airlines surveyed that would buy a MOM aircraft have defined their preferred two-class seating capacity as being 150-199 seats. Only 27% want 200-249 seats and many fewer want even larger aircraft.

Given the level of demand for a smaller jet, developing just a shrunken version of an aircraft optimized for larger capacity won't be good enough. Much investment would likely have to go into it to ensure that key design features such as wings, empennage and engines fit its size and are optimized for the segment.

The fact that so many airlines are interested in an aircraft with fewer than 200 seats makes clear that many ultimately consider the MOM aircraft a replacement for Boeing 737 or A320 fleets, and not only a model for a new segment. In fact, only 18% of airlines responded that they would use such a jet to open new markets as a pure addition to their fleets, while most cited replacement (35%) or some combination of upgauging or downsizing of average unit capacity. The new midsize aircraft is not only about filling the niche created by the discontinuation of the Boeing 757; airlines go far beyond that narrow application in their planning.

But Boeing or any other manufacturer may not choose that route because there would be a clear danger of cannibalizing existing aircraft families. In Boeing's family, definition work will all depend on how it sees the 737's future. The company could assume that, with average aircraft size increasing anyway, the new design could over time become its smallest offering as 737 production slowly decreases. Or Boeing could conclude that the current 737 will be succeeded in its own segment with the midsize aircraft.

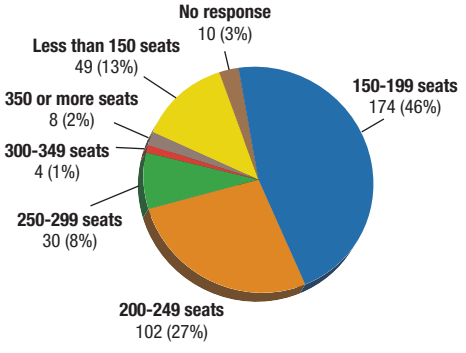
That second path would require a massive capital investment, which would be challenging, given all of Boeing's other burdens—recovery of 787 development costs, plus 737 MAX and 777X development. The midsize aircraft would likely have to be developed as a family of different versions to satisfy as many airline and lessor demands as possible.

But who says Boeing will be the one to build an aircraft in that segment? Airbus will soon be much less constrained in terms of spending: The A350-900 is already in service, and the -1000 will follow next year. Investment on a possible stretch will likely be more incremental, and most of the work on the A320neo family is also behind it.

Then again, Airbus probably already has what comes closest to airline requirements in that part of the market, the A321neo and A330neo. Why would it risk making them obsolete unless absolutely necessary?

But airlines are clearly showing their interest: 89% of airlines and air cargo operators surveyed said they would buy a MOM aircraft. And 82% of those that are interested can imagine buying it before 2023.

Number of Seats Preferred by Operators Interested in MOM Aircraft



Based on 377 positive responses of airlines and air cargo operators

Sources: BofA Merril Lynch Global Research, Aviation Week

Gallery *See more results from the survey:* **AviationWeek.com/MOMSurvey**

By Graham Warwick

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COMMENTARY

Work in Progress

AERONAUTICAL DEVELOPMENT AGENCY

B for effort, B for capability, but India's Tejas could develop into an A-grade fighter

More than 30 years in development, India's first two Tejas light fighters entered air force service on July 1. The Tejas Mk. 1 is late and falls short of its requirements. But it has created an industrial ecosystem better positioned to deliver planned upgrades and future aircraft than India had three decades ago.

The Tejas is usually compared with regional rival Pakistan's JF-17 Thunder, the product of a Chinese industry now on its fifth generation of jet fighter. Technically, perhaps the best benchmark is against the products of other industries new to building combat aircraft. These are Korea Aerospace Industries' (KAI) T-50 and Taiwan's AIDC F-CK-1—similar in size if different in origin.

AIDC's experience before the Indigenous Defense Fighter (IDF) program began in 1982 was designing the AT-3 jet trainer (with Northrop). Lockheed Martin (then General Dynamics) provided assistance, and thus the IDF resembles the F-16. KAI's experience before beginning work on a supersonic trainer in 1997 was license-building the KF-16, and the T-50 was developed with Lockheed—hence its similarity to the U.S. fighter.

India had experience license-building Soviet and Western aircraft when it launched the Light Combat Aircraft (LCA) program in 1983, but its design credentials were limited to Hindustan Aeronautics Ltd. (HAL) developing the supersonic HF-24 Marut in the 1960s and improving the Folland Gnat light fighter as the Ajeet in the 1970s. To develop the LCA, the government established the Aeronautical Development Agency to bring together Indian industry and institutions, with Dassault as an early advisor.

Aircraft development does not go fast in India, but the Tejas program has been painfully slow. Taiwan's F-CK-1 became operational in 1997, 15 years after formal launch; Korea's T-50 in 2005 after nine years; and Pakistan's JF-17 in 2007 after eight years. The 33 years it has taken India to field the Tejas is extraordinary by comparison. But there is a mitigating factor.

The arms embargo imposed in 1988 in response to India's nuclear tests cut off access to U.S. suppliers, most critically Lockheed for the digital flight controls. This forced India to develop its own fly-by-wire system. Other delays were due to India's failure to develop key systems indigenously as planned, including the Kaveri afterburning engine and multimode radar.

The consequence is that rather than being 70% indigenous as planned, the Tejas is 65% imported. This includes the General Electric F404-IN20 engine and Israeli Elta EL/M-2032 radar, as well as cockpit displays and flight-control actuators originally to have been developed in India.

The bulk of the delays came before the first of two LCA technology demonstrators flew in 2001—18 years after launch compared with seven years for the IDF, five for the T-50 and four for the Chengdu FC-1/JF-17. But the pace did not pick up much. India flew another 12 prototype and preproduction aircraft before achieving limited initial operational clearance (IOC) in 2013.

How does it compare? The Tejas ticks the boxes for a modern fighter: digital fly-by-wire, multimode radar, composite structures. The aircraft has a U.S. engine and Israeli radar, versus Russian and Chinese, respectively, in the JF-17. However, the Tejas is overweight, with a similar empty weight to the JF-17 but for a smaller aircraft. It is underpowered on its 19,000-lb.-thrust F404-IN20, so speed, acceleration and maneuverability fall short of specification. Insufficient internal fuel capacity limits its range.

The Tejas Mk. 1 does not yet have full operational capability (FOC), which adds inflight refueling and a new radome to increase radar range. FOC is hoped for by 2020, when the full complement of 40 Mk. 1s is scheduled to be delivered. The IOC Mk. 1 is armed with Russian R73E short-range air-to-air missiles and laser-guided bombs. FOC will add the Israeli Rafael Derby beyond-visual-range missile, now in firing tests.

India is working on a redesigned Tejas Mk. 2, powered by a 22,000-lb.-thrust GE F414-INS6, to meet the original requirements, but now the air force plans to buy 80 improved Mk. 1As as a next step. This will add Elta's EL/M-2052 active, electronically scanned array (AESA) radar and an electronic-warfare pod, as there is no room for the planned internal self-protection jammer. Weight will be trimmed slightly.

HAL plans to fly the Mk. 1A prototype in 2018 and complete deliveries by 2025. It also has to ramp up production to 16 a year from eight—no easy task for the state-owned manufacturer. But, as New Delhi says, the Tejas has cost just $1.1 billion to develop—$2.1 billion including the carrier-based naval version—so it already deserves an A for affordability.

By Frank Morring, Jr.

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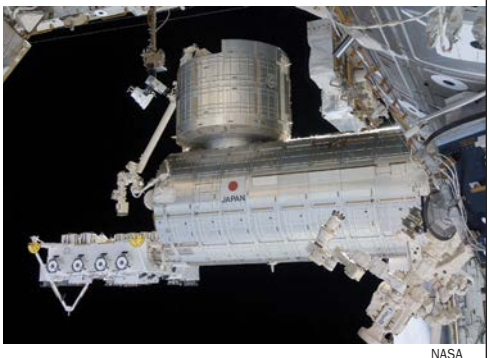
COMMENTARY

Staying the Course

Space station persistence is paying off for Japan



NASA

Japan is teaching the spacefaring nations of the world a valuable lesson with its Kibo experiment module: Make a plan, and stick with it. Even before Russia joined the "Space Station Freedom" development in the 1990s, Japanese engineers liked to joke that they started with the smallest module in the station design and wound up with the largest without changing its size.

The basic design Japan chose while its partners were downsizing to meet budget constraints is in orbit today, proving its worth as the most capable research facility on the International Space Station (ISS). While the sum is greater than the whole on the ISS, Kibo (see photo), the Japanese Experiment Module usually called "JEM" in astronautese, goes well beyond the partners' facilities in what it can do on its own.

Europe's Columbus lab, Russia's Zarya/Zvezda combo and NASA's Unity, Destiny, Harmony and Tranquility pressurized station core all essentially provide a shirtsleeve environment for humans and specialized research racks, power and data links. JEM has all of that, plus an exposed "porch," an airlock that opens onto that "exposed facility," and a robotic arm that can move stuff around on it. It has some very sophisticated scientific racks—with more on the way—a pair of big windows and even an attic for storage.

"JAXA [Japan Aerospace Exploration Agency] has many unique capabilities for research on [its] portion of the space station," says William Gerstenmaier, NASA's associate administrator for human exploration and operations. "They focus on areas such as protein crystal growth, the habitat for fish as a model organism, the centrifuge that will enable studies of partial gravity effects on living organisms and an external platform for Earth and space observation instruments on the JEM Exposed Facility."

Biologists are particularly excited about the fish, the centrifuge and, when they arrive, the mice already on JAXA's manifest. At a workshop on JEM capabilities held in San Diego ahead of the fourth ISSR&D Conference, U.S. and Japanese officials touted the advantages for life-science research of complex organisms that can be returned to Earth alive to help scientists study how their bodies adapted to microgravity.

JAXA has installed a small centrifuge in JEM to provide a 1g environment for six mice that will serve as controls for six more to be left in microgravity during a months-long exposure. One of the first experiments aims to identify how gene expression changes after long-term microgravity, and to study the genetic effects of spaceflight on offspring produced on Earth with sperm from mice that have been in that environment.

Meanwhile, Japan is running aquarium experiments in JEM on two species of fish well-characterized on Earth—medaka and zebra fish. The minnows can be maintained for as long as 90 days, allowing two or more generations to be reared in space. Researchers have found mineral loss similar to that seen in humans when the fish bones are not subjected to gravity loads, and unusual swimming behavior as the exposure to microgravity extends.

JAXA has been improving the quality of protein crystals it can produce for designer drug research back on Earth, a research tool pioneered on NASA's space shuttle. Japanese engineers have ground-tested a magnetic furnace for JEM that can hold molten metal balls suspended for future microgravity studies of how they react to various heating and cooling inputs.

Under terms of the ISS partnership agreement, NASA already uses about half of JEM's equipment space for its own research. In December, the U.S. and Japanese agencies signed an agreement designed to expand that cooperation even further, so taxpayers in both nations can see a bigger return on their investment in the hardware.

"Their voices are becoming louder and louder every year," says Takashi Hamazaki, head of JAXA's human spaceflight technology directorate.

Under the "OP3" deal—short for Open Platform Partnership—JAXA and NASA will pursue more collaborative research "inside and outside" JEM and use ISS resources to expand cooperation with developing nations such as Vietnam in the Asia-Pacific region. Ultimately, the OP3 approach will support new uses for the station, including a Japanese experiment in capturing a dead spacecraft and finding new uses for JAXA's HTV cargo carrier, Hamazaki says.

"I think it is appropriate now, as we shift toward research, that we strengthen our cooperation with JAXA," says Gerstenmaier.

JAXA, NASA and all the other ISS partner agencies must justify their use of public money for expensive space projects. The prestige—and the outside support as demonstrated by the OP3 deal—that JAXA has gained by sticking to its original plan as much as possible, regardless of short-term priorities, can be a lesson to politicians everywhere who hold the purse strings for spaceflight.

By Michael Bruno

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COMMENTARY

Anti-Airliner Fire

With a bill to bar U.S. airliners for Iran, does the House have a grudge against Boeing?

The House of Representatives—the nexus of Export-Import Bank opposition in recent years and home to budget sequestration's largest advocacy block—is taking another swing at Boeing, this time with a bill to bar commercial aircraft sales to Iran.

The Republican-controlled House has passed language pushed by Peter Roskam (R-Ill.) that, if enacted, would block the Treasury Department from issuing a license necessary to sell any commercial aircraft to Iran. It also would keep U.S. banks and other lenders from issuing loans to Iranian companies to buy them. The amendments were added to an underlying appropriations bill by voice vote on July 7, meaning there will be no record of individual votes—and it is also usually indicative of general agreement on a measure.

U.S. TREASURY DEPARTMENT

Indeed, Roskam asserts, House Democrats "did not mount any significant opposition, and in many cases, joined efforts to block the sale." That may be true, or it may just be similar to the times Republicans have so often joined in increasing the federal debt ceiling in recent years: Sometimes it's just better to keep your mouth shut. Either way, the House is on record against the announced Iranian deals, and the move could affect most if not all major airliner sales.

Advocates for allowing the Boeing deal say it is foolish to cede business to Europe's Airbus Group, Russian OEMs or even the Chinese (in the next decade). Moreover, if Chicago-based Boeing is otherwise following the law—i.e., obtaining licenses—then lenders, including Ex-Im, should also be allowed to engage in legal business with Iran. Plenty of other adversarial countries buy U.S. airliner products, starting with Russia and China, they add.

Opponents stress Iran's terrorism ties, traditional "death to America" foreign policy and use of commercial aircraft in pursuing both. "Iranian civilian aircraft that the U.S. had sanctioned for transporting cargo on behalf of the Islamic Revolutionary Guard Corps have made nearly 200 flights to Syria since the nuclear deal was signed in July 2015," say American Enterprise Institute analysts Paul Bucala and Ken Hawrey. In a July report, they write that Iranian air forces are inadequate for such projection, leaving the 117 legacy Western commercial aircraft at Mahan Air, Iran Air and Yas Air to bridge the gap (see photo).

Regardless, to become law the GOP-controlled (barely) Senate must agree verbatim to the House language and President Barack Obama must forgo a veto. Neither is expected to go along readily. Indeed, both backed the nuclear deal, for which trade was a major incentive, including a carve-out of sanctions for Iran Air. As no final appropriations are expected before the November elections, or even possibly until the next session of Congress in January, look for the debate to continue in 2017.

MR. SMITH OF WASHINGTON

After nearly 20 years in office, the top Democrat on the House Armed Services Committee is reflective. "There are not a lot of strategic national thinkers in Congress right now," Adam Smith (Wash.) says. Along with increased political polarization, he says the legislative branch has become as parochial as it has ever been.

The problem for the military is that so much of its budget, weaponry and infrastructure is rooted in local interests, Smith says. Lawmakers see the Defense Department as more important for jobs in their districts than for national security. Compounding the back-home effect is that Congress has a hard time prioritizing threats, and the military's nature is to see them everywhere. Missions and tasks are added but never removed. All of this is bad enough, but the 2011 Budget Control Act's spending caps remain law into the early-2020s, near-term compromises notwithstanding.

So when Smith is asked about the Pentagon's technology outreach and so-called Third Offset technology efforts, he wonders where the money will come from. He suggests spending less than a trillion dollars to modernize the nuclear triad, as well as not making the Army and Marine Corps troop levels larger than what can be financially sustained. Says Smith, "I don't think there's that broader sophisticated thinking, and I think we need it."

UNSOLVED MYSTERY

On July 8, the FBI said it was finally giving up on the D.B. Cooper case. The dapper "Dan Cooper," as he called himself when buying the ticket, infamously hijacked a Northwest Orient Airlines flight in November 1971 before parachuting into the night rain, apparently over southwestern Washington state, with about $200,000. The bureau needs the manpower elsewhere, regardless of the seemingly endless public tips it receives. Says a spokeswoman: "To solve a case, the FBI must prove culpability beyond a reasonable doubt, and, unfortunately, none of the well-meaning tips or applications of new investigative technology have yielded the necessary proof."

Big Bet Gone Wrong

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Airbus is making deep cuts to A380 production, a move many see as the beginning of the end for the largest civil aircraft

Jens Flottau Farnborough

On Dec. 19, 2000, Jean-Luc Lagardere, co-chairman of the newly formed EADS, stood in front of a big crowd in Toulouse where he and his German colleague Manfred Bischoff had just announced the launch of the biggest commercial aircraft ever—the A380. "We will achieve superior profitability," Lagardere confidently predicted. And Bischoff said with equal certainty: "There is a sufficient market" for the aircraft that would transform air transport much like the Boeing 747 did in the 1970s.

At this year's Farnborough Airshow, Airbus CEO Fabrice Bregier had the rather unpleasant task of amending these statements. The A380 is still decades away from recovering its development costs, in a best-case scenario. But whether it will reach that point became even more doubtful when Bregier conceded that—at least for now—the market is not nearly as big as the founders of EADS had hoped. EADS was later renamed Airbus Group.

Because of the slow pace of orders for the A380, Airbus is severely curtailing production. The manufacturer is currently producing 2.5 aircraft per month. It turned out only 27 aircraft in 2015. The output will go down to 20 in 2017, and just one aircraft per month in 2018. Airbus's $20 billion-plus bet at the turn of the century that it was going to break Boeing's monopoly in the very large aircraft market is about to go terribly wrong. That decision is rapidly turning into a prime example of market misjudgment and bad timing.

Instead of being the first aircraft in a new era of air travel, the A380 is now increasingly perceived as the last of an old era when big was beautiful.

In some respects, the A380 is the victim of Airbus's own success. Back in the old days, lower unit costs were mainly achievable by making aircraft larger. But since the introduction of the A380, major efficiency gains have been realized by engine manufacturers that enable airlines to operate smaller widebodies such as the A350 and Boeing 787 at unit costs similar to those of the A380. Emirates Airline President Tim Clark says even the 777-300ER comes near the A380 in terms of cost per seat mile.

But if there is no need to operate large aircraft to drive down costs, why take the risk of having more seats that one must sell on any given flight?

Bregier, of course, thinks differently. He believes that general air traffic growth and constraints at key airports will require airlines to upgauge aircraft size regardless of the cost argument. "The trend is with us," he said.

The problem is that the argument may make sense in theory, but too few airlines are following it in reality.

By ramping down A380 production, Airbus is giving the theory another 2-3 years to come to fruition while applying a tourniquet to the flow of red ink on the program. If orders still do not come in by then, the question will no longer be about how many aircraft are produced, but when production will end.

More and more, observers are convinced that discontinuing the program is unavoidable. The rate cut "looks like the beginning of the end," Teal Group analyst Richard Aboulafia says. "I cannot imagine any market or technology changes that would cause sales to recover. The best they can do is to find a face-saving way to terminate the program."

Emirates Airline is by far the largest A380 customer, with 142 aircraft on order and 81 in operation.

Airbus has firm orders for 319 A380s, 193 of which had been delivered by the end of June. The backlog is 126, of which 61 are for Emirates Airline and can be considered a safe bet. However, the picture shifts when it comes to the remaining 65 aircraft. In fact, orders for around 40 aircraft look shaky. The backlog still includes orders for 20 aircraft from lessor Amedeo, which has not yet placed the aircraft with any operators; 10 aircraft originally planned for Hong Kong Airlines (and now listed for an undisclosed customer); six for Virgin Atlantic; and three for now-defunct Transaero. It appears to be highly unlikely that Hong Kong and Virgin will take delivery of their aircraft. A further two aircraft are listed for Air France, but the carrier has already made clear it does not intend to accept them.

Most of the existing big operators such as Lufthansa, British Airways and Qatar Airways say they will not take more than their original orders.

What is more, a preliminary commitment from Iran Air for 12 A380s announced in January does not appear to be turning into a firm deal.

Bregier remains confident, at least officially. Airbus plans to keep A380 output at low levels "for a few years before we can ramp back up again," he said at the Farnborough Airshow. He insisted that he sees "big upside potential" in the program in spite of the announced scaling back.

Bregier sees two reasons why production could be boosted again at some point. He argues that Emirates will eventually have to replace its existing fleet, which will grow to 142 aircraft in the next few years. After all, Clark has often made clear that the carrier would want to replace the aircraft with the A380 again, ideally with an A380neo, and that an order for up to 200 aircraft is possible.

But the fact that the A380neo proposal has been shelved for several years is further evidence that Airbus's confidence in sales prospects for its flagship aircraft is dwindling. It is unclear now whether a renewed push for sales would be based on the current aircraft or a reengined version in the medium term. "It is up to the market," Airbus sales chief John Leahy says. "If fuel goes to $100 again, everybody will be banging on my door for a Neo."

However dramatic the A380 crisis may look, it is unique. The rest of industry (and the Airbus portfolio) are nowhere near crisis mode.

Leahy insists that "this aircraft is a natural for the market." By 2030, production rates of 30-40 aircraft per year could be possible again, the Airbus COO believes. Of course, that was also the production level anticipated shortly after the planned market introduction 10 years ago. Projecting such optimism for 25 years later is a further indicator of Airbus's misjudgment.

The much more short-term challenge is to keep program costs under control. Bregier says Airbus knows it can profitably build 20 A380s in 2017, down from the current level of 27. He indirectly concedes going to 12 will not be profitable: "I don't say we will break even at 12." On the other hand, he emphasizes that the losses incurred at that low production rate "will not be material for Airbus."

However dramatic the A380 crisis may look, it is unique. The rest of the industry (and the Airbus portfolio) are nowhere near crisis mode. Airbus recorded additional firm orders for 197 aircraft and 72 commitments at Farnborough for a total of 419 this year. Leahy believes that "we are firmly on track for a book-to-bill ratio of one"—which is in line with the official targets.

Archrival Boeing remains confident about narrowbody demand and is still oversold, even at its target production rate of 57 aircraft per month, Chairman/CEO Dennis Muilenburg says. But he notices "some hesitancy in the widebody market" driven by slow trade and cargo weakness. He says he still expects a book-to-bill ratio of "about one," although the timing of orders is "sometimes hard to predict." Boeing plans to deliver around 750 aircraft this year. "But building order backlog is not my big worry this year," he says. At Farnborough the company announced new firm orders for 20 aircraft and commitments for another 120.

The slowing pace of orders, combined with negative interest rates in parts of Europe and political uncertainties in the U.S. and U.K., has raised questions about how much steam is left in the commercial aircraft industry's upturn. "It looks like the cycle is peaking," said one investment banker on a visit to Farnborough. And some suppliers are nervous about committing to the hefty investments needed to support the robust production increases planned by Airbus and Boeing.

"Suppliers are nervous about the commercial aerospace [upcycle] and are cautious about adding incremental capacity," Bank of America Merrill Lynch analyst Ronald J. Epstein wrote from the airshow. "Overall, we thought the tone and tenor of the event were pessimistic, and we get the sense that the industry is bracing for a downturn."

Conversely, suppliers are also scrambling in the near term to meet sharp upturns in production at aircraft manufacturers and engine manufacturers Pratt & Whitney, GE, CFM and Rolls-Royce. "What we're hearing now on jet engines is 'crank it up, crank it up,'" says Klaus Kleinfeld, chairman and CEO of alloys giant Alcoa. "We have all hands on deck."

—With Joe Anselmo in Farnborough

Check 6 *Aviation Week editors discuss commercial aircraft events (and more) at the Farnborough Airshow :* **AviationWeek.com/podcast**

Stretch Goals

Clearer picture of Boeing 777X, MOM and 737 MAX development plan begins to emerge

Guy Norris Farnborough

A further stretch of the 777-9X is technically feasible, says Boeing.

Farnborough 2016 may have been devoid of new aircraft launches, but it did at least open a wider window on Boeing's future commercial aircraft development strategy, including the potential go-ahead of a further stretch of the world's longest airliner.

On the top of nearly everyone's agenda is tracking the developing saga of Boeing's middle-of-the-market (MOM) study and the company's narrowing focus on the sweet spot of a family of aircraft with 200-270 seats and a range of up to 5,100 nm. The aircraft, which is potentially targeted at entry into service in 2024-25, is being researched to fill the space between today's Airbus A320 and Boeing 737 category and the medium-capacity twin-aisle A330, A350 and Boeing 787.

Boeing believes the broader potential market, including the upper-end 737 replacements and lower-end widebody purchases, could be as large as 5,000 aircraft, of which 2,000-3,000 represent the heart of the MOM sector. That assessment was also borne out in the responses to a recent survey by Aviation Week, Penton Research and Bank of America Merrill Lynch.

"The survey validates a lot of the things we are hearing," says Boeing Commercial Airplanes (BCA) President Ray Conner. "We are in the process of taking all of that and figuring out how we address those areas and what we want to do." The company is assessing how to "[m]ake the business case work. . . . There are a lot of things to do. We are still in that process of driving those things out. The larger GTF [geared turbofan] plan will likely feature a higher gear ratio than the current family's 3.5:1."

In the smaller capacity sector, Boeing has confirmed plans to revamp the slow-selling 737-7, the smallest of its new reengined MAX family, by adding extra seats. The company downplayed recently reported studies of a larger variant of the 737-9 to compete directly with the Airbus A321neo. "We are finalizing the size of the 737-7 and will increase it by two seat rows, or about 12 seats bigger than the 737-700 Next Generation," says John Wojick, Boeing sales and marketing vice president. "People ask 'why'? Because our large customers for the 737 have all voted, including Southwest and WestJet, and they want an airplane that produces more capability, more range and more seat count than the airplane they both operate today. So we are officially increasing the size of that aircraft."

The revised design will include a 76-in.-longer fuselage to accommodate the additional seat rows, the

Power Plan

GE9X materials tests forge pathway to potential 787 engine upgrade package

Guy Norris Farnborough

With Boeing starting assembly of the first 787-10, the final member of the 787 family, General Electric is studying a "next-gen" upgrade for the aircraft's GEnx-1B engine that will leverage technology under test for the much larger GE9X in development for the 777X.

The potential upgrade, if approved, is aimed primarily at reducing maintenance costs and improving reliability rather than targeting fuel consumption. The package will be introduced as a block change to form a new build standard, although content and timing of the improvement plan have yet to be determined. The upgrade will not occur, however, before the completion of FAA Part 33 certification of the GE9X, scheduled for 2018.

"The technology for the next-gen GEnx is hiding in plain sight," says Bill Fitzgerald, vice president and general manager of GE's Commercial Engines Operation, referring to a suite of new materials aimed at the GE9X that are under scaled test using a GEnx donor engine. These are focused on an array of hot-section parts made from lightweight ceramic matrix composites (CMC). "We are sitting at 3,200 cycles of demonstrated capability that has a CMC combustor in it, stage 1 and 2 nozzles and CMC shrouds," he adds.

Other potential parts of the upgrade include rotating CMCs that have been tested already for possible military applications. GE conducted trials of an F414 low-pressure turbine with blades made from the heat-resistant material in 2015 as part of the U.S. Air Force Research Laboratory's Adaptive Engine Technology Demonstrator program.

BOEING

plans for which were unveiled at the air show following negotiations with 737-7 launch customers Southwest Airlines and WestJet; they will now convert their orders to the revamped configuration. The aircraft will also have additional range and improved hot-and-high performance. Studies of the larger variant, dubbed the -10X, are continuing but face the hurdle of higher development costs associated with modifying the main gear to provide ground clearance for the larger CFM Leap 1A/C-derived engine that would power the variant. "Is the development really worth the cost for just 15% of the market?" asks Wojick.

At the other end of the capacity scale, Boeing also confirmed it is studying a further stretch of the 777X-family currently in development and says such an extension would be relatively easy to accomplish. "It is pretty straightforward for us," says BCA's Conner. "We have the 777-9X and the -8X, and this could be an extension of the family depending on what the customers really want." Boeing is about to begin construction of the 406-passenger 777-9X, which is the first and so far largest planned member of the new 777X family. The -9X is scheduled to enter service in 2020, and its shorter, 355-passenger 777-8X stablemate is due to follow in 2022.

At 251 ft. long the 777-9X already edges out the 747-8 as the world's longest airliner, but a further stretch would ensure the 777X's status as the largest twinjet ever developed. In comparison, the current 777-300ER is 242 ft. long, and the rival Airbus A350-1000 is about 237 ft. in length.

Despite their huge size, the General Electric GE9X engines in development for the 777X produce less thrust than the GE90-115Bs that power the baseline 777-300ER. However, the GE9X will be rated at 102,000-105,000 lb. thrust for the -8X/-9X and will likely have adequate margin for the relatively modest fuselage stretch thought to be under consideration for the growth version.

For now, Boeing is not specifying how large the extended version -10X—might be. "It's more about what customers want and whether we can satisfy that with a stretch of the airplane. We will just play that one as the customer desires," says Conner. "We have the ability to do it. The neat thing about it is we have a great airplane. The -8X being the size of the 777-300ER and with incredible range capability [along with] the big -9, there's nothing, at least at this point in time, to compete with that. If somebody wanted more capacity, it is a pretty straightforward deal for us to do."

"It's all about how you use the technology investment over and over again," says Fitzgerald. "The commercial side is benefiting quite a bit from the investment on the military side. We are in the process of evaluating that now, and it really depends on what data we get out of the tests," he adds. "We are being much more disciplined about when we let these things into service, so we are not racing to get there. We want to make sure that when we get there, it is right."

By the time final decisions are made on the content of the upgrade, "we will be 6-7 years into service, and we will know a lot about how the asset is performing," says Fitzgerald. "In the beginning. it was all about fuel efficiency, but now it's about aircraft utilization and maintenance costs. What is the data—Boeing's or GE's—telling us to do?"

GE's move comes as Rolls-Royce prepares to begin flight tests of its own upgraded variant of the 787 engine, the Trent 1000 TEN (Thrust, Efficiency and New technology). The evaluation, which is expected to begin next month on a 787 development aircraft, follows receipt of European Aviation Safety Agency certification earlier this month. The TEN incorporates a scaled version of the advanced compressor developed by Rolls for the Trent XWB-84 used on the Airbus A350, as well as other technologies perfected on the company's Advance3 demonstrator. The hybrid engine was launched for the stretched 787-10 in 2012 but will also become the standard production engine for all 787s starting next year. The TEN is designed to improve fuel burn by 2% over the current Package C production standard.

An engine testbed for GE9X technologies could pave the way for a "next-gen" GEnx-1B.

GENERAL ELECTRIC

Video *Take a tour with Guy Norris of the big fan engines at Farnborough:* **AviationWeek.com/FIAEngines**

Official Backing

Moscow, Beijing increase likelihood of long-range widebody progressing

Maxim Pyadushkin Moscow and Bradley Perrett Beijing

An intergovernmental agreement has endorsed development of a proposed Russo-Chinese widebody airliner, defining the program as an equal partnership between United Aircraft Corp. (UAC) and Comac.

The agreement must raise the chance of the so-called Long-Range Wide-Body Commercial Aircraft (LRWBCA) entering full-scale development but appears not to launch the project. The terms are vague and there is no commitment to a specific investment, which is left for later agreement. The Russian side earlier estimated the program's cost at $13-20 billion.

In 2014 Comac and UAC began preliminary development of the aircraft, which would be broadly comparable with the Airbus A330 and go into service in the mid-2020s. Under the intergovernmental agreement signed on June 25, the program will be managed by a specially formed company to be owned equally by the two state manufacturers.

According to UAC CEO Yury Slusar, the joint company will be registered this year and will design, sell and support the airliner. Investment in the program will flow through the company, which another UAC representative says will be registered in China—specifically, in a free-trade zone in the Pudong district of Shanghai. Comac is based in Pudong.

The deal between Moscow and Beijing calls for UAC and Comac to set up a joint engineering center. The distribution of work under the program, such as manufacturing, will be defined later.

The organizational arrangement follows that of Comac, which develops commercial aircraft, markets them and supports them in service but contracts fabrication to suppliers—mostly Avic units for the structures. Similarly, the joint widebody company can be expected to look to Russian and Chinese suppliers for airframe parts and, at least to some extent, onboard systems. A foreign engine is very likely to be needed, at least for the initial versions of the LRWBCA. Comac performs final assembly on its aircraft. No plan for the LRWBCA final assembly has been revealed.

Comac is unenthusiastic about the project, say industry sources in China. The Chinese manufacturer would prefer to create its own widebody to follow the C919 narrowbody it is developing. But the LRWBCA proposal has been driven by the governments—and it will presumably go ahead as long as the leadership of the two countries are determined that it should.

Russian industry is far keener than Comac and is willing to take on most of the design work. According to UAC's latest annual report, in 2015 the group's subsidiaries conducted technical research on various aspects of a future widebody long-range aircraft. This work was financed by the Russian government and included research on avionics, aerodynamics, composite wings, fuselages, landing gear and fuel systems. One UAC design bureau, Tupolev, studied the feasibility of applying the more-electric-aircraft concept to the future widebody, minimizing the use of hydraulics, while another, Ilyushin, looked at developing a new airliner by deeply modernizing the Il-96-300.

UAC and Comac engineering teams have separately worked out concept designs that should now be reconciled, says the UAC official. "The results of this will enable us to pass Gate 2 procedures this year," he says. A Gate 2 milestone usually means the approval of the preliminary design.

Exact parameters of the aircraft cannot yet be specified, because the design effort is at a very initial stage, the official says. But he adds that designers are working on a basic configuration that would be able to carry about 280 passengers more than 12,000 km (7,460 mi.). Fuselage width is almost the same as the A350's, and economy seats would be nine abreast, according to concept design specifications seen by Aviation Week last year. Engines of 71,226-75,000-lb. thrust were specified.

"We hope that the aircraft will make the maiden flight in 2021 and will be certified by 2025," says the UAC representative. A preliminary schedule previously set out plans for a first flight in 2022 and entry into service in 2023-25.

UAC

Concept designs for the LRWBCA from UAC and Comac should be merged this year.

The partners may begin selecting suppliers as soon the preliminary design is approved. Requests for proposals to potential suppliers are expected to be sent this year, a representative of Technodinamika, a Russian specialist in aircraft subsystems, tells Aviation Week. That company has been awarded a contract from Russia's ministry of industry and trade for development of eight subsystems for widebody long-range aircraft that could be used for the Russo-Chinese program in the future. They include the electric system, cockpit air conditioning and pressure system and inert-gas generation system, as well as fire protection, deicing and oxygen systems.

The aircraft is to be certified by Chinese and Russian airworthiness agencies; there is no mention of endorsement by the FAA or European Aviation Safety Agency. This would be an issue not only for exports: Chinese airlines are keen to see Western endorsement on type certificates, even for locally developed aircraft.

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Global Ambitions

Qatar Airways proposes LATAM, Meridiana buy-ins

Cathy Buyck and Jens Flottau Farnborough

Qatar Airways is actively expanding its investment portfolio, clinching deals with both a Latin American and Italian airline in one week.

Qatar Airways is famous for its aggressive, organic growth strategy aimed at expanding Doha, the country's capital, into a massive global long-haul hub. But its most recent investment is not for new aircraft: The Qatari national airline announced at the Farnborough Airshow a $613 million deal for a stake in LATAM Airlines Group and its intent to buy 49% of Meridiana.

The equivalent of adding three widebody aircraft turns Qatar Airways into one of the largest shareholders of Latin America's biggest airline group at a time when LATAM faces financial difficulties due to Brazil's economic crisis. The investment is the airline's second major consolidation move. Last year, it acquired a 9.9% stake in International Airlines Group, the parent of British Airways, Iberia, Aer Lingus and Vueling; it boosted the stake to 15% this year.

"We want to have a network of partnerships," Qatar Airways CEO Akbar Al Baker tells Aviation Week. "We will be stronger in feeding each other."

He says his company "recognizes short-term challenges in some of LATAM's market," but he remains confident in its long-term prospects. "LATAM will only improve." He points out the LATAM decision was made after thorough analysis of the group's brand, network and markets. It is an "exciting" opportunity to invest and to develop its long-term relationship with the leading Latin American carrier, he insists. Qatar Airways and LATAM are both part of the Oneworld alliance. British Airways and Iberia are Oneworld members, and LATAM also has a joint business agreement with both for routes between South America and Europe.

Al Baker wants to take "time to see how we can work together." The first cooperative steps, once LATAM shareholders approve the deal, will include more codeshares and aligning service standards, LATAM Airlines Group CEO Enrique Cueto says.

The group will schedule an extraordinary shareholders meeting by Sept. 2 to vote on Qatar Airways' proposed investment. If shareholders consent, the state-owned Persian Gulf carrier will subscribe a capital increase of $613 million through the issuance of new shares at $10 per share.

Cueto says he "personally admires" Qatar for its strategy and concern for passengers. "The investment recognizes LATAM's achievements and supports our projects for the future," he says. In addition to strengthening our financial position, it will allow us to explore new opportunities for connectivity with Asia and the Middle East."

The Santiago, Chile-based group lost $219.3 million in 2015, doubling its $109.8 million 2014 deficit. Net debt was $11.4 billion as of Dec. 31, 2015. To address the situation, it is implementing cost-saving initiatives and cutting capacity, including its Brazilian domestic operations, by 10-12% for the full year 2016. It is also reducing capital expenditures and preserving liquidity by restructuring its fleet assets and lowering fleet commitments up to $3 billion for 2016-2018.

LATAM Airlines Group was formed by the merger of LAN Airlines and TAM Brazil, and it is introducing a unified LATAM brand across its several subsidiaries in the region.

Several Latin American airlines have recently opened up to foreign investors, seeking fresh capital to counter current troubles: Azul is partly owned by United Airlines and HNA Group, and Delta Air Lines and Air France-KLM have stakes in low-cost carrier Gol. Avianca's majority shareholder, Synergy Group, recently indicated it is open to talks about adding another investor; United and Delta are reportedly taking a close look.

On July 14, two days after announcing the LATAM deal, Qatar reached agreement with Meridiana's parent company Alisarda to purchase 49% of the Sardinian carrier. Negotiations with the struggling Italian airline have been going on for some time—a memorandum of understanding was signed in February—but appeared stalled after unions protested a staff reduction necessary to bring the airline back to profitability.

Qatar says the contribution and shareholders' agreement is subject to fulfilment of "certain conditions" before the closing—planned for early October—without providing details. Al Baker admits he is unwilling to accept repeated staff strikes and indicates he wants "the Italian government and Meridiana to assure us such actions will not happen again." Qatar will "not accept being blackmailed by staff. We want to grow the airline," he said on the sidelines of the LATAM announcement at the Farnborough Airshow, adding that the deal "will include a walk-away clause. We have this in each agreement. We did use it with Cargolux."

The airline purchased a 35% share in Cargolux in September 2011, making it the second-largest shareholder after Luxair, but sold its stake a year later after disagreements with unions, management and other shareholders about the cargo carrier's strategy.

Al Baker says the airline is looking for other potential investment targets. "We will take it step by step. I cannot disclose all of our plans in one go." He has previously said Qatar could buy a stake in Royal Air Maroc to expand its connectivity in Africa.

Qatar is the second of the three big Gulf carriers to step up its investment efforts in foreign carriers. Etihad Airways owns stakes in Alitalia, Air Berlin, Air Serbia, Darwin Airlines, Air Seychelles, Jet Airways and Virgin Australia and is considering buying a 49% stake in Air Malta. Emirates is focused on its own operations.

Spending Spree

Britain signs on the dotted line for P-8A Poseidon, AH-64E Apache helicopters at Farnborough

Tony Osborne Farnborough

Who would have thought that when David Cameron spoke on opening day of this year's Farnborough Airshow, his speech here would be his last.

A new prime minister, Theresa May, is settling into her role of leading the U.K. out of the European Union and into a new reality.

Britain is simplifying its weapon inventory, with Brimstone set to be the direct-fire air-to-ground weapon for Typhoon, Apache (pictured) and the new Protector UAV.

Despite the radical political upheaval in Britain after the Brexit vote, the country's defense plans are beginning to take shape, with the U.K. looking to return to its status as a more reliable and capable defense partner.

British defense ministers used the air show to sign up for nearly £5 billion ($6.6 billion) of new equipment as the decisions taken in last year's Strategic Defense and Security Review (SDSR) translate into reality.

Through U.S. Foreign Military Sales, the U.K. will buy 50 remanufactured AH-64E Apache attack helicopters, at a cost of £1.78 billion, and nine P-8A Poseidon maritime patrol aircraft for £3 billion. Britain also firmed up plans for its complex weapons programs and funded new support measures that will ultimately help boost the capability of its Eurofighter Typhoons.

And ministers say that in four years, with the arrival of the F-35 Joint Strike Fighter, the U.K. will once again be able to project power from its two new Queen Elizabeth-class carriers.

"Some people might say after Brexit that England is retreating into its shell," says Philip Dunne, minister for defense procurement. "But this will demonstrate to the world that Britain is not retreating. . . . We are back and we will be an important ally for our partners in NATO. I think this is an important message to get out into the world," he adds.

Senior U.S. commanders used the Royal International Air Tattoo to declare their own confidence in Britain's ability to remain a strong defense partner. Threats of further cuts to the U.K.'s defenses last year had prompted a number of senior U.S. military figures to speak out against continued British defense austerity.

"I am convinced Britain will remain a strong defense partner," says U.S. Air Force chief Gen. David Goldfein. "It is a little too early to make long-term predictions about how this will all play out, but I will tell you, I remain optimistic," he adds. "I have heard no one talk about backing off an inch to their contributions to the NATO alliance."

But these new purchases come at a significant cost. Britain's eagerness to quickly fill a long-standing capability gap in maritime patrol and airborne anti-submarine warfare—created by the retirement of the BAE Nimrod MR2 in 2009 and the cancellation of its replacement, the Nimrod MRA4, in 2010—will cost £3 billion over 10 years.

That amount will pay for introduction of the P-8A capability including aircraft—in standard U.S. Navy configuration—personnel, infrastructure, support and training, as well as a package of consumables, such as weapons or sonobuoys. There are no plans—at least in the short term—for British-made consumables. A £100 million training and support facility will be built at RAF Lossiemouth, Scotland—the main operating base for the Poseidon fleet—so that U.K. crews can be trained independently of the U.S. training system.

The current cost of the P-8A aircraft for the U.S. Navy is about $150 million, although a contract for 13, including four for Australia announced last August, put the price of the jet at about $114 million.

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Dunne says the U.K. deal is one of the most "keenly priced" P-8A procurements yet. The U.S. Navy says the British are paying the same price as the U.S. for the aircraft, plus a governmental transaction charge and fees to paint the aircraft in British colors.

But there are questions about its overland surveillance capacity. Critics are also unhappy with the lack of U.K. work on the jet and that Britain could be forced to give up other capabilities such as the Sentinel standoff radar

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platform to help pay for it—despite the Sentinel being considered the government's current "go-to" platform to support coalition operations.

It has been suggested that British industry could develop a belly-mounted sensor payload for the P-8A to replace the ground surveillance capability of Sentinel. According to the SDSR, Sentinel is due to be dropped from the fleet about 2022.

Taking Apaches from the U.S. production line is also controversial. However, U.K. helicopter manufacturer Leonardo—formerly AgustaWestland, which built the British Army's existing Apache fleet—should still get a look in terms of future support. Defense Minister Michael Fallon has said he wants to see the new Apache fleet maintained in the U.K. and that British companies ought "to do most of the work."

TONY OSBORNE/AW&ST

The renewal of a long-standing partnering arrangement between the government and Leonardo should soothe the pain. Defense officials say they plan to spend up to £3 billion with the company over the next decade just on helicopter support and upgrades.

Leonardo may also benefit from funding for the development of an unmanned rotorcraft, according to CEO Mauro Moretti. Although this has yet to be formally confirmed, local member of Parliament Marcus Fysh says the partnering arrangement is backed by "initial seed funding" for future products.

The Defense Ministry says the Apaches will be new-build airframes, but to reduce costs the new fleet will recycle components from the existing fleet. As much as 60% of current aircraft will be reused, including the Longbow fire control radar and the Modernized Target Acquisition and Designation System.

The U.K. will also break with tradition and use the General Electric T700 engine rather than the Turbomeca RTM322 from the current fleet. This is the first time the U.K. military has bought an off-the-shelf GE engine. The helicopters are also likely to be armed with MBDA's Brimstone missile following June's firing trials.

The first British AH-64Es are due to come off the production line at Mesa, Arizona, in early 2020 and will begin entering service in 2022; the existing fleet of Apaches will be phased out of service in 2023-24.

For its part of the deal, Boeing has promised to create an additional 2,000 jobs in the U.K. toward its goal of being an "enduring industrial champion." The company has agreed to make the U.K. its European base for training, maintenance, repair and overhaul (MRO) across its defense, fixed-wing and rotary platforms. There will be additional bidding opportunities to work on company programs for U.K. suppliers, it says.

Boeing's commitments could look more tangible by year-end, as it begins to seriously examine prospects for permanent facilities, probably at a U.K. airport where it can perform that MRO and training work, bringing together several facilities dotted around the country into one location.

The Defense Ministry also used the Farnborough Airshow to announce new support contracts for its Eurofighter Typhoon fleet. The Typhoon Total Availability Enterprise (TyTAN)—previously known as the Future State Operating Model—will flow any cost savings into capability development of the aircraft. BAE Systems and its partners—including Leonardo—believe TyTAN could allow the U.K. to stream £500 million back into the fleet, paving the way for additional enhancements such as new weapons and upgrades to defensive aids. The SDSR states that two additional Typhoon squadrons will be formed toward the end of the decade, when the Panavia Tornado GR4 is retired from service.

Britain is also looking again at its training needs, in light of the decisions taken in last year's SDSR to boost the number of combat aircraft in use. In February it was announced that the U.K. Military Flight Training System would purchase a fleet of 38 new fixed-wing training aircraft, including 23 Grob 120TPs—to be known as Prefects—along with 10 Beechcraft T-6C Texan IIs and five Embraer Phenom 100s. That aircraft count was generated from pilot requirements based on the 2010 SDSR, which shrank the number of fast-jet squadrons. However, the uptick in defense spending prompted by last year's SDSR and the increase in the number of combat aircraft—along with the P-8A buy—may prompt a need for more training aircraft, or for their daily utilization to increase.

Britain's nine P-8As will be configured the same as U.S. Navy aircraft and use U.S. weapons and sonobuoys.

The U.K. Defense Ministry is also looking at the future of its contracted training capability and studying options for an umbrella contract for fixed-wing training.

The Air Support to Defense Operational Training requirement—the first of two phases of which are expected to get underway in 2020—will see a selected commercial operator deliver red air aggressor and electronic warfare training across the U.K. armed forces, replacing a number of individual contracts with an umbrella contract with a single operator, which could be worth £1.2 billion over 15 years.

Two F-35s fly a sortie over the U.K. ahead of the jet's debut at the Royal International Air Tattoo at RAF Fairford, England.

JAMIE HUNTER/AVIACOM

Out of the Storm?

F-35 proves it can deploy outside the U.S., but now the program must manage a global network of maintenance and data sharing

Lara Seligman Farnborough

Two years after an engine fire thwarted the F-35's planned debut in the U.K., the jet has proved it can deploy overseas, with appearances at three major European air shows in the last two months. Now it is up to the policy makers to tackle the thorny logistics of operating a fifth-generation fighter program across 12 different nations, each with unique infrastructure and security requirements.

The next challenge for Lockheed Martin's Joint Strike Fighter (JSF) program will be establishing a framework for synchronizing maintenance and operations of the world's first "smart" fighter fleet. By sharing data across the coalition, militaries that fly the F-35 will be able to track and analyze critical information—from repair and maintenance trends to the movement of hostile actors across a region. The difficulties stem from participating nations' desire to protect both the native industrial base and sovereign security data.

As officials struggle to balance the need for efficiency with national interests, the commander of U.S. Air Forces in Europe and Africa is urging the allies to put aside policy disagreements and take advantage of the new technology.

"What continues to give us the asymmetric advantage is the ability to do command and control; the art is to be able to move information from machine to machine—uninhibited by policy," says Gen. Frank Gorenc, commander of U.S. Air Forces, Europe. "The asymmetric advantage of our alliance, of our country, is going to depend on the ability to take advantage of multidomain."

The JSF officially stepped onto the international stage in June at the Netherlands Leeuwarden Air Show, and continued its European tour with showstopping appearances at the U.K.'s Royal International Air Tattoo and Farnborough Airshow. The crowd held its collective breath as the fighter hovered over the runway, and it burst into applause after the jet touched down for a vertical landing at RAF Fairford, England.

Although the jet has now proven its ability to operate outside the U.S., questions remain about how the program will manage its worldwide repair and maintenance enterprise.

As part of the global sustainment plan, the Joint Program Office (JPO) has divided the world into three zones—North America, Europe and the Asia-Pacific region—with the intent of establishing regional hubs for airframe, engine and various component work.

North America's F-35s will be built and maintained out of Lockheed Martin's Fort Worth facility. But the JPO is still firming up a blueprint for overhauling aircraft in Europe and the Pacific, according to JPO Chief Lt. Gen. Christopher Bogdan.

The JPO has said Italy will provide Europe's heavy airframe maintenance out of a final assembly and check-out (FACO) facility in Cameri. Meanwhile Turkey, Norway and the Netherlands will build depots for heavy engine work. In the Pacific, Japan and Australia will be responsible for heavy airframe and depot maintenance, with Japan agreeing to stand up its own FACO out of Nagoya.

But none of that is necessarily set in stone, Bogdan cautions.

"We are always looking for best value, so over the next 3-5 years as the capability is stood up in those countries, we will continue to assess if the program is achieving best value," Bogdan says. "If not, then we will take a look at what we need to do in those locations to increase our efficiency and effectiveness, or if we have to invest elsewhere."

Some countries are going rogue, signaling they want to perform all heavy maintenance on the jets in-country, instead of at preestablished regional facilities. Israel, for instance, has plans to stand up an F-35 logistics center at Nevatim Air Base, and top Israeli officials say the aircraft will leave the country only for combat missions.

Video *See the F-35B's flying—and hovering—display at the Farnborough Airshow* **AviationWeek.com/FIAF-35B**

CROWN COPYRIGHT

An F-35 over RAF Fairford performed a flyover with an aerial refueling tanker and demonstrated hover and vertical landing at the Royal International Air Tattoo.

Meanwhile, the U.K., via a joint BAE Systems, Northrop Grumman and state-owned Defense Electronics and Components Agency team, is making a bid to become the F-35 avionics sustainment hub in Europe. The U.K. is laying the groundwork for a Freedom of Action facility where workers can apply stealth coatings and perform other crucial maintenance work on British soil.

At the same time, Rolls-Royce will soon be getting its hands on Pratt & Whitney's F135 engine. Though the U.K. has not officially announced any intent to build an engine depot, the latest agreement between Rolls and Pratt for support work on the U.K.'s F-35B engines at RAF Marham, England, gives the British company the opportunity to potentially expand coverage beyond the LiftSystem technology for the U.S. and international fleets.

On the other hand, smaller countries such as Norway and the Netherlands are counting on cost savings and efficiencies generated by the shared sustainment enterprise. Norwegian F-35 pilot Lt. Col. Martin "Tintin" Tesli says Norway does not have the resources to independently sustain its fleet in-country and doing so would eat into crucial aircrew flight hours.

"In the end, a model will have to come out, I think, for all of our nations that offers value and drives down cost, and if that's not the case, then [I doubt] a proposition will be able to stay alive," says Lt. Gen. Dennis Luyt, new chief of the Royal Netherlands Air Force.

Though the plan is still evolving, the JPO is looking to make some decisions on the European and Pacific hubs for component repair by November, Bogdan says. Over the next few years, the partners will continue to evaluate the best locations to maintain the jets' electronics, avionics, and hydraulic and mechanical support equipment.

Lockheed, which manages the storage and distribution of F-35 parts worldwide, understands the need to tailor sustainment for each nation that flies the new fighter jet, says Jeff Babione, the company's F-35 program manager.

"Where do you want to do the maintenance? How do you want to do the maintenance? What kind of control do you want?" Babione asks. "We try to be as flexible as possible."

Although Lockheed is responsible for managing the allocation of parts around the world through the Autonomic Logistics and Information System (ALIS), the U.S. government actually owns the components, a construct that generates efficiencies and cost savings for all the partners.

But ALIS presents its own set of policy challenges. Through the internal logistics system, Lockheed theoretically is able to track the status of each part of each aircraft worldwide. But the fact that Lockheed and the U.S. government now potentially have eyes on sovereign information does not sit well with some foreign militaries.

Each country has the ability to filter what fleet information—specific aircraft location or failure incidents, for instance—is shared via ALIS to the rest of the world, says David Scott, Lockheed's vice president of business development and strategy for training and logistics solutions. The data is distilled as it rises through the ALIS hierarchy, so that participating nations have the option to provide failure information without identifying all the details of the incident.

Lockheed is working through complex cyberanalysis and strict policy regulations to develop solutions that fit the needs of each customer individually, says Babione.

"How do we make sure that no one else can see information from other countries? It's a complex cyberanalysis as well as very clear government-to-government rules for how to share that information," Babione says. "Each country has a decision to make about what information they want

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to share or not share, and so we work with those countries to enable ALIS to do that kind of tailoring."

But by firewalling certain information, the partners may be limiting the potential of the fifth-generation capability.

"The information gives us a broader perspective on how the fleet is performing as a whole, so if a country chooses not to share that information, then we have less ability to understand what their trend analysis and reliability challenges are and not as much ability to help solve those issues," says Scott.

The more information a fleet can provide Lockheed through ALIS, the easier it is to help the customer work through failures and reliability challenges, Scott says.

Fat Girl

China reportedly wants a bigger successor to its new airlifter

Bradley Perrett Beijing

INTERNATIONAL AVIATION

Avic ceremoniously began Y-20 deliveries in June.

Developing a big airlifter in nine years would not be a bad performance for an experienced manufacturer of jet transports. For Avic, which has begun deliveries of the Y-20 Kunpeng, turning out the 200-metric-ton (440,000 lb.) aircraft in that time looks like quite an achievement.

The program has laid a foundation for future large-aircraft programs, say state media, which also report that another, bigger airlifter is planned. Avic was already known to have proposed a smaller airlifter, the Y-30.

The four-engine Y-20 was delivered in June and entered service in July with the Saturn D-30KP medium-bypass turbofan or a local version called the WS-18. A later version of the aircraft should be powered by the Chinese WS-20 high-bypass turbofan. Deliveries have begun earlier than expected, maybe earlier than the air force expected. In 2013, two military academics who likely had knowledge of the program said the type could not enter service before 2017. The aircraft, in the weight class of the Ilyushin Il-76 but wider and shorter, first flew in January 2013 (*AW&ST* Feb. 4, 2013, p. 26).

The Y-20 program began in 2007, says Xinhua news agency, apparently referring to the beginning of full-scale development. The approximately nine-year program compares with the 8.5 years that Boeing predecessor McDonnell Douglas needed for the 265-metric-ton C-17 Globemaster, which was powered by a military version of Pratt & Whitney's PW2000.

Y-20 flight testing took 41 months, compared with 21 for the C-17. That suggests thoroughness, but the number of flight-test aircraft is unknown, as is the extent of difficulty encountered.

Development of the Airbus A400M Atlas—smaller than the Y-20 but featuring a new turboprop engine—took 10 years. Kawasaki Heavy Industries began deliveries of the C-2 in June, after 15 years of development. The C-2 is about as big as the A400M but uses the very mature General Electric CF6-80C2 engine.

Unlike Boeing and Airbus, Avic has not previously completed development of aircraft of anything like its new airlifter's size. Extensive predevelopment, beginning in the early 1990s, must have helped shorten the Y-20 program. And Avic probably had much Ukrainian help, since Antonov began acting as a consultant to the Chinese group around the turn of the century.

There is no report on when the Y-20 may be operational. At least two units were present at the acceptance ceremony, showing the narrow nacelles of the D-30KP. They were painted in a dark gray much like the shade the U.S. Air Force uses for its strategic airlifters. Markings included the air force insignia, a large national flag on the tail fin and, on the forward fuselage, "Chinese Air Force" in Chinese characters. In the designation, "Y" stands for "yun," meaning transportation. "Kunpeng" means "roc," an enormous mythical bird of prey. Xinhua says the aircraft's nickname is Fat Girl.

"The broader the pool of information, the more thorough and robust the analysis is," he says. "But we believe the benefits of providing some level of detail will be obvious to most users and they will take advantage."

The crucial next step for the JSF is figuring out how to synchronize both logistics and threat data across the coalition to make better, faster tactical decisions, says Goldfein.

"That's the fundamental question of the future: How do we work our way into a common operating system?" Goldfein says. "So that information-sharing data analysis and being able to rapidly decide and act on that information becomes the foundation of our asymmetric advantage."

The four-engine Y-20 is a product of the Xian works of Avic's large-airplane division, Avic Aircraft. It has a wingspan of 45 m (147 ft.) and payload of 66 metric tons. Gross weight has been stated as greater than 200 metric tons, probably for the WS-20 version, which should have at least 20% more thrust.

Final assembly is done in Xian. Major parts are built at the same plant, the Observer, a Shanghai news service, reported last year. Other parts come from airlifter specialist Shaanxi Aircraft Corp., which is another unit of Avic Aircraft, from the Chengdu and Shenyang plants of Avic's fighter division and from Harbin Aircraft, which belongs to Avicopter.

"More than 1,000 Y-20s will be needed," says the head of Avic's Large Aircraft Development Office, Zhu Qian, citing U.S. and Russian experience. The figure is surprising. The U.S. has 222 C-17s and 46 Lockheed Martin C-5s.

"This project has accumulated valuable experience in the area of large-aircraft development," says Xinhua. "It has produced a high-quality team of personnel that can steadily move forward with complex organization of large-scale engineering. This lays a foundation for future construction of large aircraft."

One will be bigger, says the *China Daily*. "China will also develop transport jets that are even larger than the Y-20 and comparable to the Lockheed C-5 Galaxy from the U.S. and the Antonov An-225 Mriya, designed in the former Soviet Union," the paper states without attribution.

The report must be treated with care, however, since the *China Daily* is prone to making mistakes on aerospace subjects. The 640-metric-ton An-225, the world's largest aircraft, is not at all in the same class as the 381-metric-ton C-5, nor does China have any obvious reason to build an airlifter three times the size of the Y-20.

Shaanxi Aircraft, builder of the Y-9 turboprop airlifter, exhibited a model of the Y-30 in 2014. That aircraft, comparable to the Hercules and Embraer KC-390, had then progressed only as far as a concept design, and even the choice between jet and propeller engines had not been made. Although officials say the air force wants the Y-30, it is not known to have entered full-scale development.

Rig Ready

AFRL evaluations lead way toward follow-on three-stream engine development initiative

Guy Norris Los Angeles

General Electric and the U.S. Air Force are starting tests of advanced compressor and fan rigs that will pave the way for a follow-on development and test program of full three-stream, adaptive combat engines.

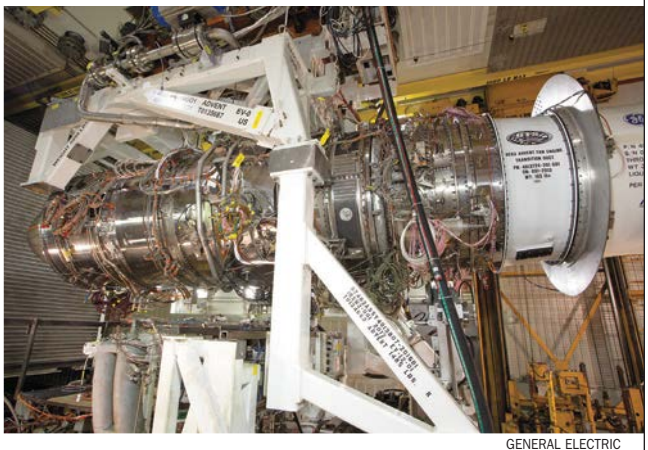
The rig tests, which will run for the next five months at the Air Force Research Laboratory's Compressor Research Facility at Wright-Patterson AFB, Ohio, form a bridge to the start of a possible full development and procurement program for adaptive engines for future Air Force and U.S. Navy sixth-generation fighters.

Three-stream engines are multirole. The engine is designed to provide additional mass flow for increased propulsive efficiency and lower fuel burn during cruise. When combat power is required, they must be able to change configuration to provide additional core flow for higher thrust and cooling air. This morphing capability is considered vital for increasing both the range and high-speed performance of future U.S. fighters and may even be used to reengine Lockheed Martin's F-35 Joint Strike Fighter in the 2020s.

The first concrete steps toward development of an adaptive production fighter engine were taken on June 30 when initial contracts valued at $2 billion were awarded to GE and Pratt & Whitney for the Adaptive Engine Transition Program (AETP).

For now, however, the focus is on testing the building blocks of the new variable-cycle engine concepts under development by the two U.S. engine-makers. Conducted under the Adaptive Engine Technology Development (AETD) program, the tests will validate key elements of these future three-stream engines and are the culmination of an effort begun by GE in 2012.

Revealing new details about the test plan, Dan McCormick, general manager of GE Aviation Advanced Combat Engine programs, says: "The compressor rig will run through the rest of the summer and into the early part of the fall. As soon as that rig is finished, we'll remove it, and install the fan rig, which also will run for a couple of months. We expect the fan rig to be done at the end of this year or early 2017 at the latest."



GENERAL ELECTRIC

The AETD compressor and fan are derived from designs tested by GE under the Adaptive Versatile Engine Technology (Advent) program.

The compressor is full-scale while the fan rig is a partial-scale version of the actual engine-size fan, now targeted at an eventual production engine in the 45,000-lb.-thrust range suitable for installation in the F-35. "That is related more to hardware costs and facility capability in running a scaled fan, which is a typical approach we use," says McCormick.

The compressor rig tests are aimed at proving designs for higher stage loadings, which will be capable of producing the far higher compression ratios required by future adaptive engines. Much of the design know-how for these higher-performing cores spins off commercial engines such as the CFM Leap-1 and GE9X. "It is closely tied to the temperatures and pressure ratios that we can run in the engine, which are derived from commercial development programs," says McCormick.

Details of the number of stages and targeted performance goals remain under wraps. "We cannot specify the number of stages, although it is in the range of what normal combat engines are used to seeing. The compression ratio numbers are classified. It is a high OPR [overall pressure ratio] compressor, but the number is classified. Stage loading is the name of the game, and we are doing that using our latest aerodynamic capabilities. We're getting more compression in a smaller space compared to legacy engines," he avers.

While mechanical details of GE's adaptive-cycle architecture also remain closely guarded, it is known that the major sections of the engine translate fore-and-aft during the transition from one phase to another. The resulting change in the center of gravity, added to the requirement to fit within the existing F-35 engine bay, represents "a significant challenge," says McCormick. "We worked for about a year trying to optimize the configuration for mechanical interface, weight and center of gravity. I think we have come to a good solution for the F-35 if the Air Force and Defense Department choose to move forward with an application to that airframe. I am very comfortable with where we have ended up today. Lockheed verified we have good compatibility in those three areas."

Beyond AETP, GE "will continue to mature the design of the AETD architecture," he adds. A detailed design review is scheduled for late 2017, followed by the release of drawings for building a full engine. GE expects to build three test engines starting in 2019. The first engine will be used to evaluate the basic mechanical design, the second will assess performance and operability, and the third will vet durability.

AETP, scheduled to run through 2021, involves potential options for actually installing an adaptive engine in an F-35. "There is an option for an installed ground run, in which one of the ground test engines is installed in an aircraft for systems-integration information that we can't get in a test cell," says McCormick. "There is another option of performing a flight demonstration. The Air Force will decide if they want to execute any of those options," he adds.

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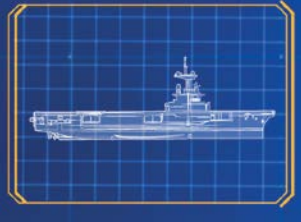

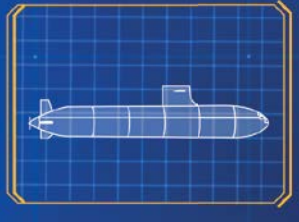

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Additive Investments

Alcoa and Hexcel make statements with manufacturing initiatives

Michael Bruno Pittsburgh and Washington

If Alcoa was known for providing aluminum, then soon-to-be Arconic—its coming spinoff serving aerospace manufacturing and other industries—wants to be known for something else: problem-solving via additive manufacturing (AM).

Hexcel Corp., the leading aerospace composite materials provider, may be seeking a similar reputation if another recent announcement is any indication.

Since the summer started, both companies have unveiled major new initiatives featuring AM, sometimes called 3-D printing. On May 31, Hexcel announced a "strategic" buy-in at Oxford Performance Materials (OPM). The privately owned company produces thermoplastic, carbon fiber-reinforced 3-D-printed parts for commercial aerospace and defense applications.

Alcoa opened its 3-D-printing metal powder production plant in July at its technology campus outside Pittsburgh.

ALCOA

Details of the financial commitment were not provided, but executives say the investment creates a partnership between the Connecticut-based companies to "advance the commercial application of this growing manufacturing technology to serve the aerospace market."

Specifically, the money will go to joint business development efforts and to expand OPM's production capacity under its Oxfab technology platform. OPM says it is the first company to successfully apply AM with polymer polyetherketoneketone.

"Hexcel represents the gold standard in carbon fiber and composite material technologies, and our core target markets are extremely complementary," says OPM Chairman and CEO Scott DeFelice.

"With the adoption of these lightweight, high-performing materials expected to accelerate, this is an ideal opportunity for our two companies to work together, enabling faster product development and adoption for our customers," says Hexcel Chairman, CEO and President Nick Stanage.

Meanwhile, on July 6, Alcoa formally unveiled its 3-D-printing metal powder-production facility at the Alcoa Technical Center just outside of Pittsburgh, the world's largest light metals research center. Under Arconic's coming quasi-materials-agnostic approach, it will produce proprietary titanium, nickel and aluminum powders specifically for 3-D-printed aerospace parts.

Alcoa says the plant is part of a $60 million investment in advanced 3-D-printing materials and processes and builds on its AM capabilities in California, Georgia, Michigan, Pennsylvania and Texas. Along with producing powders, the company is targeting other additive techniques, including its recently unveiled Ampliforge process, a hybrid technique that combines additive and traditional manufacturing.

Ampliforge is a suite of post-printing processes that will take a nearly complete additively manufactured part and treat it using traditional manufacturing techniques such as forging, improving performance through a "best-of-both-worlds" production approach. Hot isostatic pressing is another applicable process.

Alcoa says Ampliforge can enhance the properties of 3-D-printed parts, for example by improving microstructure to increase toughness and strength, when compared with parts made solely through additive manufacturing. Producing near-net parts by 3-D printing, meanwhile, reduces the metal used in forgings. Alcoa is piloting the technique at its Pittsburg technical center and in Cleveland.

Alcoa is expected to deliver its first AM parts to Airbus soon for use in commercial airliners under a deal unveiled in April. "Airbus gave us the first contract that they have ever given out for commercial pieces on the airplane," Klaus Kleinfeld, chairman and CEO of Alcoa, told Aviation Week in June.

Other companies are unveiling AM-related financing, too. On June 30, Norsk Titanium AS, one of the earliest suppliers of aerospace-grade 3-D-printed structural titanium parts, announced the successful close of its second-quarter 2016 funding round.

According to Norsk, that included a $10 million equity investment from midmarket private equity firm Insight Equity Holdings, another $10 million via a debt facility from Harbert European Growth Capital Fund I and a combined $5 million equity investment from a "number of smaller investors."

"We chose to invest in Norsk Titanium because their Rapid Plasma Deposition technology is heralded as one of the most disruptive processes in additive manufacturing, and their strong management team makes it a real game changer in a sector so often bereft of true innovation," says Johan Kampe, senior managing director at Harbert.

The $25 million funding round follows $125 million to support the development of Norsk Titanium's Plattsburgh, New York, factory, which is part of Norsk's proposed $1 billion, 10-year project in the state. Those funds were provided by New York State as part of its 2016 budget.

Health Checks

Tier 1 suppliers adapt to rate demands and cost pressures from aircraft manufacturers

Graham Warwick Washington and Michael Bruno Wichita

For the aircraft industry's Tier 1 suppliers, supporting the product development and production ramp-up plans of Airbus, Boeing and others while meeting manufacturers' demands for cost reductions has put the sector into turnaround mode as it seeks both savings and growth.

One of the biggest Tier 1s, Spirit AeroSystems with net sales of $6.64 billion in 2015, is emerging from a revamp engineered by former Lockheed Martin executive Larry Lawson, who retires at the end of July after just three years as president and CEO.

Now Triumph Group, with net sales of $3.89 billion for the year ended March 31, is entering a turnaround spearheaded by Dan Crowley, a former executive at Lockheed Martin and then at Raytheon, who was appointed president and CEO in December.

That Lawson followed Crowley as head of first the F-35 Joint Strike Fighter (JSF) program and then Lockheed's Aeronautics unit is just one of many connections in a Tier 1 sector where supplier positions on multiple programs with multiple manufacturers is the sought-after recipe for success.

Those connections include Spirit's transfer of its loss-making Gulfstream wing work in Tulsa, Oklahoma, to Triumph in December 2014, and Triumph's rise as a supplier on the F-35 with a July agreement making it a second source for engine and structural components.

For new Spirit CEO Tom Gentile, who joined the company in April from GE Capital, the main tasks are to craft a long-term contract with primary customer Boeing—responsible for 85% of the company's revenue—while cutting costs in its own supply chain by pursuing "should cost" price deals. Gentile says he will do these things while maintaining planned share buybacks, performing on current contracts and agreed-to ramp-ups, as well as pursuing growth, particularly in business jet and defense sectors.

Crowley's task is to turn a collection of more than 40 companies acquired over the years into "One Triumph" by consolidating, closing locations, reducing costs, derisking programs and developing new offerings that combine the extant capabilities within the company.

"We are changing from a decentralized company to centralized. We are going from many parallel companies flying in formation to business lines and true P&Ls [profit and loss centers]," says Crowley. "We are linking the companies, providing a common infrastructure, resetting strategies and restarting growth, so there is a lot going on at once."

Tom Gentile, CEO
Spirit AeroSystems

Dan Crowley, CEO
Triumph Group

Triumph hopes to emulate Spirit's significantly increased profitability and cash flow over the past two years, achieved through improved operating efficiency, cost cutting and the divesting of unprofitable programs. Gentile is taking over a company that is well positioned but has challenges, including securing a new deal with Boeing, cutting supply-chain costs and finding growth.

"There is no hurry to get a deal done," says Gentile of the Boeing negotiations, as the company is working under an extension to its last 10-year agreement, signed when Wichita-based Spirit was divested from Boeing Commercial Airplanes. On supply-chain savings, there is no Spirit-wide target, he says, noting that costs can be cut at every supplier, by 5-30%. Spirit will conduct its own design reviews on outsourced parts to arrive at "should-cost" pricing, and use more dual sourcing to drive competition.

Triumph's first step is to consolidate to 22 operating companies, from 47, and cut the workforce by 8%. "We've identified the 10 factories we are going to close out of 73, and the businesses we are going to divest that are not core; we are in the implementation phase," he says.

Triumph's past philosophy was to acquire companies and let them operate entrepreneurially. "We grew 25% a year for 20-plus years, and that's quite remarkable," says Crowley. "But the company had size, and not scale. It wasn't getting the value, the 'one plus one equals three' of having all these companies."

As it was at Spirit, the first priority is to improve execution on existing programs, as a key step toward winning more business. "Delivering on commitments is our number one priority, and building a culture around performance and returning all red and yellow programs to green," says Crowley. The second priority is to become predictably profitable, avoiding further write-offs and meeting cash targets. "It's a two-year turnaround, but we'll show progress well before that," he asserts.

Triumph took a $1.3 billion charge in its fourth quarter to cover the rate reduction on the Boeing 747-8, write off development costs on the Bombardier Global 7000 wing, and other impairments and restructuring costs. "We dealt very directly with the 747, which was a rate slowdown, not a performance problem. Both the 747 and 767 are delivering on time now," Crowley says.

Bombardier in 2015 extended the Global 7000 program by two years in a move to derisk its own business. "On Bombardier, it was a choice to write off the launch of development. We still have some to go, but think we have greatly retired the risk on that program," Crowley says. "Then we have a couple of smaller programs we are still watching."

Crowley set up a program office to drive the transformation, tasked with identifying the best practices within the company and deploying them across Triumph. "They are finding that this site has the best safety practices, this one the best supply-chain management, others the best cash management, transition to production, lean manufacturing or labor relations. The good practices are out there," he says.

Key to the new strategy is growing Triumph's Integrated Systems business. This includes gearboxes, actuators, hy-

draulic, fuel and thermal systems, and full-authority digital engine controls (FADEC), areas "in which we do the kind of work where we have more design authority and add more value," he says.

Triumph has targeted cost reductions of $300 million, but Crowley also wants to take capabilities within the company and combine them into new products with higher value. "There's a point at which it is hard to take cost out of a system. You get down to the core value of the raw materials, so the step you can take in driving down not only cost, but size, weight and power, is to combine systems," he says.

"We have a design concept around a combined fuel controller and FADEC that will eliminate boxes and therefore cost and size, weight and power. Those product road maps are just now coming together as we combine businesses that used to compete, or at least not talk to each other," Crowley says. "People in the company are meeting each other for the first time. I'm constantly making introductions."

When Crowley joined Triumph, he expected to encounter 47 company presidents all telling him to keep his hands off their business. "The truth is that many of those entrepreneurial leaders have left. There are managers now that are open to a different model and see that what we have been doing hasn't universally worked. I have been pushing on an open door," he says.

"We had three or four fuel-system companies, two hydraulic companies, two in thermal systems, five or six actuation companies, so by bringing them together I get more engineering critical mass," he says, noting: "Some of these companies had become so small they were not really viable."

R&D funding is being pooled and focused on areas such as additive manufacturing. "It can transform the way we operate because we do a lot of metal removal, but we know within our lifetime a lot of that is going to go away. We have some fledgling activities there, but we need to go faster," he says.

Spirit, meanwhile, is looking at growth in a defense market that wants the affordability a commercial high-rate producer can bring. Here the company's role on Northrop Grumman's B-21 bomber program represents major new business. Gentile is also interested in the aftermarket and in providing third-party machining and fabrication for other aerospace companies.

For Triumph, working with Northrop to transition the composite wing for the MQ-4C Triton unmanned aircraft to production from a challenging development phase is critical. "Showing Bombardier what we can do on the Global 7000 ramp [up] is the next big challenge. And we can do more on the Joint Strike Fighter as the rate goes up," says Crowley. "But the calling card for what you can do is always how you are performing today."

TECHNOLOGY

Touching Experience

Multitouch technology comes to commercial transport cockpits

BOEING/MARIAN LOCKHART

The introduction of touch screens on the 777X, seen here under test in a 787 engineering cab, will mark the first use of this technology in a commercial airliner.

Guy Norris Seattle

The flight-deck displays of Boeing's 777X stretched twinjet will incorporate touch screens, marking the first time this technology will be featured on the fixed displays on a commercial transport aircraft.

Boeing says the decision to use touchscreen technology, which is currently targeted at high-end business jets and turboprops, reflects the consensus of its launch airline customer group. "They all want to go forward to a future where they have touch capability in the flight deck," says the 777X vice president and general manager, Bob Feldmann. "We think we [will have] the first airplane to make it [seem] like something they . . . use in their daily lives."

All five of the 777X flight deck's Rockwell Collins 15.1-in. landscape-format displays will have digital resistive multitouch-screen capability that will click on "finger lift." The name of the chosen touch-screen component supplier has not yet been released. Rockwell Collins has launched touch-screen technology as part of its Pro Line Fusion upgrade package, while Honeywell has developed the feature for the Symmetry flight deck on Gulfstream G500/G600 business jets.

The interactivity element follows that of the original 777 flight deck, on which the concept of a cursor device was introduced into a Boeing commercial aircraft. The pedestal-mounted cursor control devices (CCD), which include a wrist rest to steady control in turbulence, will be eliminated from the 777X cockpit. In place of the CCDs, two rotary cursor control knobs will be located on either side of the central pedestal. The devices enable pilots to move the cursor across active areas just as in the 787 flight deck. Two control knobs will also be on the electronic flight information system glareshield panel to provide dedicated interaction with the screens in navigation display format only.

To prevent inadvertent entries, Boeing is "looking at what to do with the bezel design to make sure the crew has the ability to [maneuver] it without false touches," says Feldmann, adding that in turbulence, the crew can use a tab to click through the options, as on the 787.

"Our airlines are anxious for this and, just like on the iPhone and iPad, this is multitouch so you can size the display," explains Feldmann, who notes that Boeing "worked hard with industry," to provide the capability. Referencing electronic flight bags, which include installed Class 3 devices with touch-screen features as standard, he says: "You have all this capability, and on the flight deck our customers expect more of us. We're at the right time in the program to make a configuration decision; we have and are moving out on this."

Summer Suspense

Most emissions deal criteria remain fluid

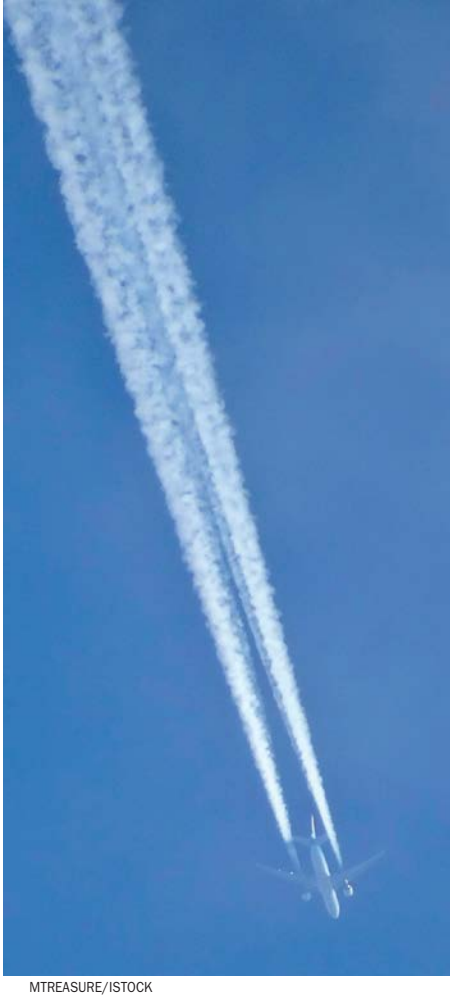
Cathy Buyck Brussels and Dublin

In three months, officials of 191 states will gather in Montreal to deliberate on a global market-based measure (GMBM) to address carbon dioxide (CO_2) emissions in international aviation. International Civil Aviation Organization (ICAO) Council President Olumuyiwa Benard Aliu says he "firmly" believes the political will exists to realize a GMBM solution at the ICAO Assembly, Sept. 27-Oct. 7.

Willie Walsh, CEO of International Airlines Group (IAG) and chairman of the International Air Transport Association (IATA) board of governors, says he, too, has a "firm, firm belief" ICAO will deal with the GMBM at the assembly. Even the European Commission (EC) is compromising; Transport Commissioner Violeta Bulc says she is convinced "the world agrees with the fact that we need to find an agreement around the MBM."

But how close to a deal are we really, and what is the deal that is being hammered out? In addition, what is happening to the European Union's emissions trading scheme (EU ETS)? Most insiders agree that including international aviation in the EU ETS was a nightmare for airlines and governments around the world; the issue overshadowed the last triennial ICAO assembly.

"The world has moved on," says Paul Steele, IATA senior vice president, while reiterating tactfully that Europe deserves credit for putting on the map the need for a GMBM addressing international aviation's CO_2 emissions. Following years of EU pressure, ICAO's member states finally committed at their 2013 assembly to develop that measure by 2016 and to apply it from 2020. As a tradeoff—and to avoid trade wars—the EU suspended its ETS requirements for flights to and from non-European countries. For 2013-16, only emissions from flights within the European Economic Area (EEA)—the 28 EU member states plus Iceland, Liechtenstein and Norway—fall under the EU ETS. Legally, it will return to its full scope from 2017 unless sufficient progress on a GMBM is made at the upcoming ICAO assembly.



MTREASURE/ISTOCK

But it is unlikely the full scope will be reinstated. The EU does not want another debacle, and the bloc's transport ministers have all made it clear the EC needs to be flexible and open to compromise on the GMBM.

"In order to avoid criticism from other ICAO countries and to avoid sending negative signals, negotiations at this stage have to focus on reaching an MBM, and stay away from the EU ETS issue," Latvia's transport minister, Uldis Augulus, emphasized at the transport council meeting in Luxembourg on June 7. His Danish counterpart advised Europe to learn from "our experience from the last [ICAO] assembly where Europe was isolated on the climate issue." The German transport minister pointed out that with 28 votes, the EU is a minority in ICAO.

The EU has only observer status at ICAO, but the EC established a common position on a GMBM on May 30 and is leading the ICAO negotiations on behalf of the member countries. The EC supports the draft assembly resolution for ICAO's GMBM presented by Aliu, Bulc confirms. For her, the outcome should be a GMBM that is nondiscriminatory and ensures significant environmental integrity. The system should not distort competition and should be effective and enforceable.

"My impression is that an MBM is not in question anymore," she says. "The world agrees that we need to find an agreement around the MBM. However, how to reach this goal is now the subject of negotiations." She adds that she expects negotiations to be "challenging," as "several important countries have signaled differing views on some key elements of the proposal tabled by Council President Aliu."

IATA wants to cap airlines' CO_2 emissions from 2020 on and is advocating a global market-based measure system to help achieve this goal.

Whether the EU ETS will remain in its current form is unclear at this stage. Simon McNamara, director general of the European Regions Airline Association, believes the whole scheme—including the current ETS that applies to intra-EEA flights—has to be scrapped from 2017 on if a deal is reached on a GMBM. Some members of the European Parliament and nongovernmental organizations support the opposite view and argue that the European regional plan (the EU considers intra-EEA as "domestic" traffic and sees the ETS in its current application as a "domestic tool" to fight climate change) is complementary to a global mechanism for international flights and should be maintained. The EC has steered away from giving a clear statement on the issue, and Bulc asserts that internal discussion on the issue can take place only when the ICAO assembly outcome is known.

The Montreal-based body did look at a global ETS when it tried to define a global MBM, but the option was dismissed because an ETS is "extremely complicated, and trying to get 191 countries to implement something like that would be almost unthinkable," says IATA's Steele.

ICAO also considered a global carbon tax on airline tickets, but this option also was rejected as being "unworkable" related to who would collect and actually distribute the money. "Sovereign states will put it in their pockets, and you will never see it again," he says.

In other words, a tax will not provide the environmental integrity that is the purpose of the GMBM: to help airlines reach carbon-neutral growth from 2020 and reduce CO_2 emissions 50% by 2050 compared to 2005.

The main proposal now on the table is carbon offsetting. ICAO prefers this option because it is simple enough to be implemented by all countries—including developing nations—and is less complex than an ETS, more cost effective than a tax or a levy and provides environmental integrity. "Carbon offsetting in itself is very simple. You do not have to do anything apart from buying carbon offset units or credits on the open market from a range of climate projects, approved by the United Nations, that cut CO_2 emissions," Steele explains. Often these projects are based in developing or emerging economies and involve fuel efficiency, renewable energy or forestry work.

While there seems to be consensus on a global offsetting scheme, many—if not most—of its design elements are still a work in progress. The major remaining issues concern the differentiation of states; the methodology and baseline used to calculate the CO_2 emissions that will need to be offset (one year or the average of emissions over a period of 2-3 years, IATA's preferred option) and the distribution of obligations.

The Aliu proposal promotes a phased approach to the inclusion of routes between certain states. There would be three levels: "A" nations (major aviation markets); "B" countries (midsize aviation markets); and "C" nations (small island states, less developed countries and landlocked developed states), with the C group excluded from the scheme. Flights between A countries will be included when the offsetting begins in 2021, while B nations would be incorporated starting in 2026.

Discussions continue on what to do when an airline is flying between two tiers and how states will be allocated into the groups. "It is [about] recognizing the different levels of maturity of aviation markets. But quite frankly, it is also about politics. It is an attempt to resolve a political challenge reflecting differentiation between developed and developing countries," Steele admits. But, he stresses, it is an enshrined principle that all operators on the same route should be subject to the same rules and the same cost base, "because otherwise you get market distortions."

China and the U.S. do not see eye to eye on this issue. China is sensitive to which side of the developed versus developing country divide it will end up on, and has thus far held back from taking an overall position on the GMBM proposal. Because of this, Chinese state-owned airlines refrained from signing the IATA resolution on a GMBM. That resolution, presented at the group's annual general meeting in Dublin June 1-3, is "urging" governments to adopt a single GMBM at the forthcoming ICAO assembly. The resolution was passed "overwhelmingly," IATA says. Aeroflot also failed to vote for it; Russia is supportive of a global levy on fuel rather than an offsetting scheme.

The ballooning exemptions and the formula to calculate if a state is in or out of the GMBM worries environmental groups

Walsh acknowledges that some of IATA's 265 airlines (comprising 83% of global air traffic) expressed reservations on some of the resolution's articles, but he insists, "they have not been about the industry's need to address climate change."

At the High-Level Meeting (HLM) with all 191 ICAO member states in Montreal May 11-13, Singapore floated the idea of a preimplementation or pilot phase for the GMBM. The reason would be to gain experience with standardized monitoring, reporting and verification processes. But watchdog organization Carbon Market Watch fears a real danger exists that such a trial period would serve only to delay full implementation. IATA also warns that a preimplementation phase should not delay the planned GMBM start date, because achieving carbon-neutral growth from 2020 and addressing the industry's emissions "is our license to grow," says IATA outgoing Director General and CEO Tony Tyler.

IATA is also "radically opposed," according to Steele, to the redistribution of emissions not covered by the scheme—as the result of phased implementation or exemptions—to those operators that are subject to the program.

The ballooning exemptions and the formula to calculate if a state is in or out of the GMBM worries environmental groups. At the HLM in May, seven states, including Singapore, objected to the use of gross national income per capita as one of the two criteria to define whether a state is included. They argued that it unfairly burdens countries with low population density. As it stands now, only states that produce 1% of global revenue ton kilometers per air operator certificate are being considered. This is a "poor measure that could lead to leaving countries such as Brazil out of the scheme," Andrew Murphy, aviation and shipping officer at Transport and Environment, points out. It further weakens the plan's coverage, and "the emissions gap could be as high as 40% in the first five years of the scheme."

Also still very much in play in the ICAO discussions is distribution of the carbon offset obligations among operators. Under the individual approach, each operator offsets its own growth post-2020. This is a bit of a challenge if you are a small, developing or fast-growing airline, Steele points out. A sectoral approach divides the total industry growth across the whole sector according to the share of emissions of the operators, whether they grow or not. A third possibility is a hybrid, with the sectoral approach transitioning to an individual one over time, or vice versa.

Can all these outstanding issues be resolved over the next 120 or so days?

"It depends very much on what kind of outcome you want. If you just want ICAO to reach a deal, things are not going too badly," Murphy says. "From our perspective, it is not sufficient that there is an agreement that people [reach] in Montreal. It needs to pass some basic minimum level of environmental credibility."

Steele is "pretty optimistic" a deal will be struck. Much of the legwork on the GMBM has been done, but he concedes the ICAO negotiations are in a difficult phase, with individual states chiming in with their own positions. "Over the summer, there will be a large number of behind-the-scenes bilateral discussions to try to broker an agreement. Hopefully on Oct. 7, smoke will appear, and we will have a market-based-measures solution for aviation. The aviation industry is fully committed to climate action and supports a GMBM."

Vision Vehicle

ESAero uses airliner concept to explore electric propulsion integration challenges

Graham Warwick Washington

Electric propulsion is in its infancy. And as in the early days of the jet, when engines were weak and thirsty, designers are trying out different aircraft configurations and propulsion architectures to see if they can find ways around the deficiencies to the promised benefits of electric drives.

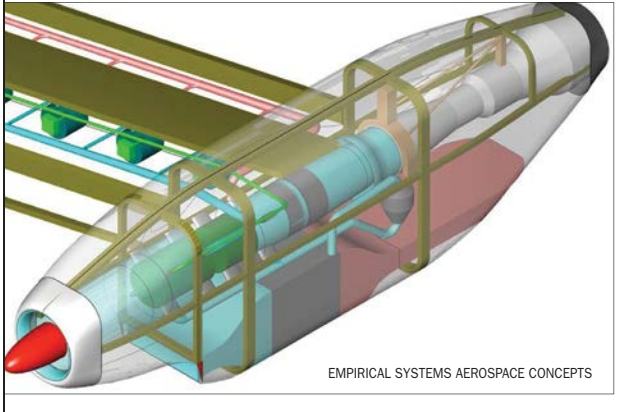
One such configuration is being studied by entrepreneurial design company Empirical Systems Aerospace (ESAero), which has been working with NASA since it started looking at electric propulsion and is now prime contractor for the X-57 Maxwell distributed electric propulsion demonstrator.

Pismo Beach, California-based ESAero originally developed its ECO-150 split-wing turboelectric distributed propulsion configuration in 2009 under a first phase of a small-business innovative research contract from NASA. Since then, the ECO-150 design has become a vehicle for understanding integration challenges and ramifications of hybrid electric propulsion, says Benjamin Schiltgen, vice president of finance.

ESAero has evolved the 150-seat EC-150 through other funded projects and in July will begin a second phase of the study to assess the configuration in more detail, including working with cost-sharing subcontractor Rolls-Royce LibertyWorks on the electrical microgrid. The company will also assess the concept's scalability to an 80-seat design, the ECO-80, which it hopes could form the basis of a future X-plane demonstrator.

The ECO-150 has two turboshaft engines mounted midspan on the wing, driving generators that power an array of 16 ducted fans embedded in the inboard split-wing sections. Fuel savings come from the effective increase in bypass ratio and propulsive efficiency of each turbine driving multiple fans.

The original 2009 concept was aimed at NASA's N+3 time frame for an aircraft entering service in 2035-40 and using superconducting electrics cryogenically cooled by onboard liquid hydrogen. The design showed the potential to reduce fuel burn by 40%, but the infrastructure required to support the aircraft was far out of reach.



EMPIRICAL SYSTEMS AEROSPACE CONCEPTS

ECO-150R is a refined version of ESAero's non-cryogenic turboelectric distributed propulsion concept.

In 2011-12, NASA and the Air Force Research Laboratory (AFRL) funded ESAero to study a dual-use commercial/military transport, to see if hybrid electric distributed propulsion could be feasible in the N+2 time frame (2025-30 service entry) using conventional noncryogenic electric machines. Projected fuel savings were less than with cryogenic superconducting electrics. "But the design closed, which was a surprise, although it did not perform too well," says Schiltgen.

In 2015, ESAero decided to take the technology advances and all it had learned and the tools it had developed since 2009 and refine the design to produce the conventional-electric ECO-150R configuration. "We end up about where the [Boeing] 737-700 is today: 1,646-nm range, 68 seat-mi./gal.," he says. "So we are about where conventional aircraft are today, but these are conservative numbers and there is room for improvement. We think the aircraft is just going to get better." Fuel savings of at least 20-30% over the 737 are projected.

The propulsion system architecture for the ECO-150R was influenced by a study performed for NASA by Rolls-Royce Liberty Works. This showed that symmetric thrust distribution can be maintained in the event of an engine or fan failure through design of the electric microgrid. This allows full power from one engine to be equally distributed to all fans if the other engine fails.

ESAero also brought thermal management into the design. At the EC-150R's power levels, the electrical components are estimated to produce nearly 1,500 kW of heat at top-of-climb flight conditions. Recirculating-liquid cooling systems with P-51 Mustang-style ducted radiators under the turboshafts cool the generators, motors, controllers and cables on each side. Cooling-system weight is estimated at 20% of electrical system weight, down from previous projections.

Turboshafts that produce 15,000 shp and each drive two generators are located in midspan nacelles with ducted radiators to cool electric components.

In its original study, to estimate lift and drag, ESAero treated the inboard wing simply as a symmetric airfoil split down the middle into upper and lower sections. But an AFRL-funded propulsion-airframe integration study by Lockheed Martin found an 8% improvement in cruise aerodynamics with similar inboard profiles, Schiltgen says,

so ESAero conducted a full 3-D computational fluid dynamics (CFD) analysis.

This study led to reshaping of the inboard wing to minimize drag while maintaining adequate volume and spacing for the electrical components. The lower surface has a shorter chord and is flattened relative to the upper surface. Fan diameter has decreased slightly and motor length decreased dramatically because of advances in the electric components since 2009. "We are not split-wing zealots, but it is working out pretty well," Schiltgen says.

The split wing with its embedded propulsion provides a powered-lift benefit due to the fans blowing over the trailing edge, and the ECO-150R needs only short-chord, short-span Flower flaps to provide high lift at low speed. "We get enough powered lift to meet the takeoff requirements," Schiltgen says.

"The ECO-150R is credible, and there is much room for improvement," he says. Some of those potential improvements will be investigated under the study's second phase, which is "not about making a product, but . . . we hope to come out with a better aircraft."

Phase 2 will include more CFD analysis. "Phase 1 was our first shot at 3-D CFD and showed it operates very closely to a normal wing, but the Lockheed Martin study also found aerodynamic improvements, so we need to do a full flight envelope study," Schiltgen says.

More work on sizing the propulsion system is planned. Where the power output of the turboshafts lapses with altitude as air density decreases, the electrical machines do not. Sizing the propulsion system for top-of-climb, as is usual, results in far more power at sea level than required, and absorbing that power drives the size and weight of the electrical system. Sizing each individual component to its particular performance requirements should significantly reduce their weight.

Phase 2 will also include a look at hybrid electric distributed propulsion,

Green Team

E170 tests focus on turbulence detection, boundary layer sensing and noise reduction

EMBRAER

Guy Norris Seattle

A suite of new technologies aimed at potential improvements in aircraft efficiency, noise, emissions and safety will be jointly tested by Boeing and Embraer later this summer as part of the U.S. manufacturer's continuing series of EcoDemonstrator flying testbeds.

The technologies, ranging from an advanced boundary layer data system to ice-phobic paint, will be flight tested in Brazil on Embraer's 170 prototype. The latest EcoDemonstrator is the fourth in the series since the program began with tests of a 737-800 in 2012, and it is the first to involve another major aircraft maker. The research initiative, which was agreed between the two companies in 2015, builds on a growing relationship that dates from 2012, when Boeing and Embraer announced a broad technical and strategic cooperative agreement.

"We've had an ongoing relationship with Embraer related to flight safety and alternate fuels, and so this year's EcoDemonstrator is going to be an E170," says Boeing Commercial Airplanes Product Development Vice President Mike Sinnett. "We've been collaborating with Embraer on flight safety areas like better runway situational awareness, energy management and common flight management approaches and biofuels. It's been a really great way of partnering with them and learning how they do things," he adds.

The broader cooperative agreement, which also encompasses support of Embraer's KC-390 tanker-transport program, included the establishment of a joint biofuel research center in the Brazilian company's Sao Jose dos Campos headquarters. The site, which opened in 2015, performs biofuel research and coordinates studies with Brazilian universities and institutions. Biofuels will be among several advances tested in the upcoming trials.

The test package also incorporates an advanced lidar (light-detection and ranging) laser system designed to act as both a detection system for clear air turbulence as well as a source of air data independent of conventional

The Embraer 170 is the first non-Boeing aircraft to be used in the EcoDemonstrator test role.

sensing systems. "Turbulence detection is my primary area of interest, but we are also looking at other aircraft applications that use air data, such as engines," says Sinnett.

The only aerodynamic feature to be tested is a revised filler shape in the cove behind the leading-edge slats of the E170 wings. "We are really good about the bulk of the slat, but there are areas where attention to detail is really important," says Sinnett, referring to the noise-generating transition areas between slats. "So we are working on unique devices to attenuate the noise. In this particular case, it is specific to the configuration of the E170, but the basic science is what we are after, to figure out how to more cost-effectively reduce approach noise without impacting aerodynamics."

Development and testing of a boundary layer data system reflects the growing importance of this technology area to both manufacturers. Careful control and monitoring of the airflow closest to the wing surface, and particularly measuring when the flow transitions do become turbulent, will be key to the success of drag-reducing technologies and laminar flow configurations being studied for future aircraft. "This is to help us understand the health of the

and using energy stored in batteries or supercapacitors to supplement the turboelectric power, and so reduce the weight of the components further.

Another part of the study will entail reducing the size of the vertical tail, and potentially eliminating it. This involves adding boundary layer ingestion (BLI) to the flattened fuselage between the V tails. Additional electric ducted fans would re-energize the fuselage wake to reduce drag and blow over an aft Coanda body flap. This blown flap would be used for longitudinal control, while the quick-acting split-wing propulsion sections would provide lateral control, allowing the tail to be eliminated.

This tailless design has been incorporated into ESAero's smaller ECO-80 concept, developed by chief scientist Darold Cummings. "Not only is BLI enabled, but longitudinal control authority seems plausible in this configuration," says Schiltgen. "Phase 2 will look at controllability. We think it is possible to demonstrate a tailless airliner." A final element will be design work on a manned ECO-80 demonstrator using a McDonnell Douglas MD-80 fuselage as a base.

"The centerpiece of all our hybrid work is the ECO-150, and it has spawned dozens of other projects related to hybrid propulsion, from vehicle concepts to tool development. This eventually led us to being prime contractor on the X-57," he says.

"Now ESAero is in the fortunate position of working on multiscale effects in both concept design and hardware. There is a compounding effect as we design, put hardware together, take lessons learned from hardware integration and reapply them to our paper designs," he says. "Each cycle comes with more and more 'aha' moments, and the rate at which we are learning how to apply turboelectric and hybrid electric distributed propulsion to various vehicle and mission combinations is astounding."

boundary layer, but it is not an airplane technology, it is an instrumentation technology," says Sinnett.

Boeing will not provide details of the data system, although in previous boundary-layer-related tests such as the recent 757 EcoDemonstrator project in 2015, the company measured the extent of laminar flow over the wing surface with infrared detectors. "That's something we are not ready to talk about yet," says Sinnett. "We are learning better how to understand the health of the boundary layer in flight test so we can match our flight-test predictions with what we actually get."

The flights will also evaluate a special ice-phobic surface treatment, conceptually similar to the anti-insect "bug-phobic" coating tested last year on the 757. "We are looking at ways to use less energy for deicing or anti-icing aircraft, and ice-phobic paint is one way of doing that," says Sinnett.

The Next Frontier

Not long after the U.K. voted to leave the European Union, BAE Systems CEO Ian King sat down with Aviation Week London Bureau Chief Tony Osborne. King, who has led the British aerospace and defense company since 2008, foresees little impact from Brexit on U.K. defense budgets. Rather, BAE expects rising defense spending in Britain and abroad and intends to expand on its role providing service and support to the F-35 Joint Strike Fighter.

BAE SYSTEMS

_AW&ST:_ So Britain decided to vote its way out of the European Union (EU). What impact, if any, will that have on BAE's business?

King: Our core markets are the U.S., U.K. and Saudi Arabia, and that is where we have our technology and IPR [intellectual property rights]. I don't see any reason why the U.K.'s defense and security policies are going to change. The Strategic Defense and Security Review was a definition of the U.K.'s defense requirements as a sovereign nation; it was unrelated to its continued membership in the EU. For the first time we have a much better definition of what [the Defense Ministry] wants and the capability requirement. This is not an issue with any immediate direct impact on our business.

But you urged your employees to vote to remain in the EU?

A number of employees asked us what the company's position was. But there is no material effect on our business. Our decision to advocate "Remain" was more about the uncertainty of not being in the EU rather than the impact on our business. If you look at our share price, the market views us as a safe haven.

Is there likely to be any impact from Brexit on the defense industry overall?

I don't see any knee-jerk reaction at all. . . . I would argue that this will be viewed as a call to arms—sorry for the pun—and will put a greater focus on U.K. exports and maintaining its defense and security postures. We have had lots of discussions, and the government's message is that it remains business as usual.

Defense budgets appear to be increasing. What is BAE's outlook?

In the U.S., the answer to that is yes, we absolutely can see that defense spending is going up from the trough it was in. When we look at our portfolio across our electronic-systems business, our ship-repair and land businesses, we are in the right spots. Saudi Arabia is continuing to mature its defense capabilities. We know it has been operationally challenged of late as well, but the only impact we are seeing is on funding.

The days of large down payments and cash advances are gone, so we will go back to normalized funding arrangements. But there is nothing new about this. We have gone through many cycles of this before and have just had to rekindle our skills at dealing with the type of bank financing used for these kinds of programs.

Britain's joint work with France on an unmanned combat air vehicle demonstrator looks like it will be extremely important on a number of levels, particularly for retaining key engineering skills.

Actually, there are a number of programs that protect that skills base. One is Typhoon, which will now stay in service until 2040—adding new capabilities, and getting the e-scan radar was a major part of that. Then there are high-end systems-engineering and aeronautical skills that apply to the unmanned arena and the joint program with France. We are also in embryonic discussions with Turkey about supporting them and their next-generation fighter. So I am not worried that there is not strong demand for the very highly qualified skills we have in this area.

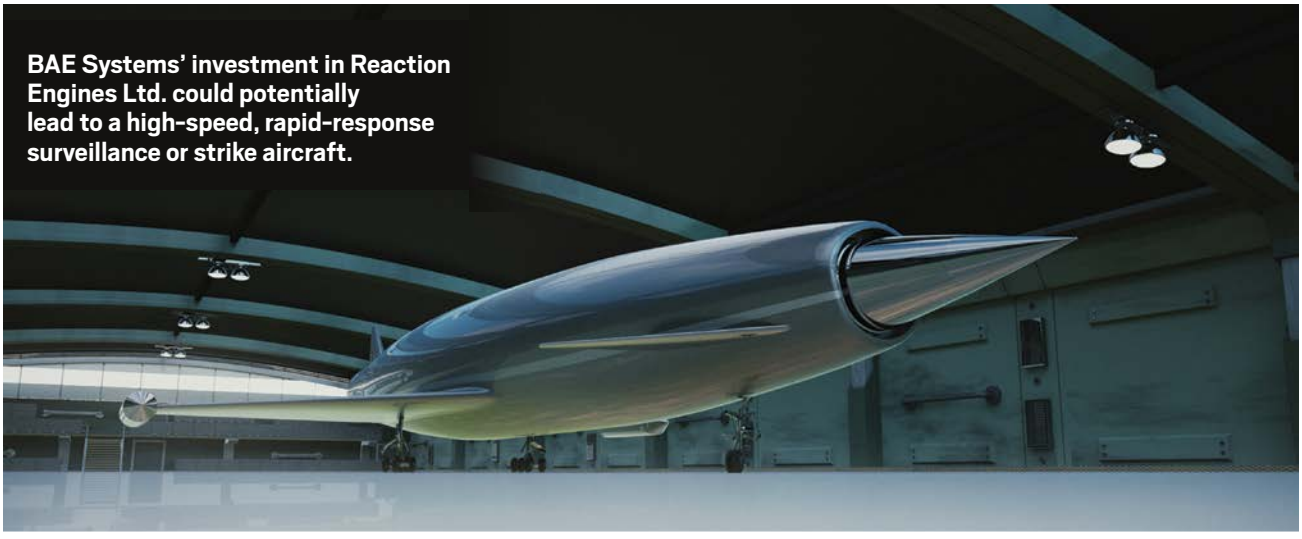
BAE has spent a fortune on developing its unmanned capabilities, yet seems determined to focus them on unmanned combat air vehicles as opposed to other potential missions and roles. Why is that?

Well, it is not quite a fortune, but we have allocated quite a bit of capital. Our view is that we want to retain our lead in this sector, but from a high-end perspective rather than the low-end perspective of surveillance drones.

Could we use these skills as this sector develops? Yes, we could, but it helps us to retain the capabilities to do more unmanned and manned as well.

There will be another manned program. . . . I am confident there will be one, though I cannot define what it is today. Unmanned is not a replacement for manned; it is in parallel with manned aircraft. I think it was an urban myth that this was the end of [the] manned industry. But there are certain missions that will make use of unmanned, and there are missions for manned, in harmony with key assets such as Typhoon and F-35.

When it comes to the next generation of manned programs, we will have the capabilities to deliver our custom-



BAE Systems' investment in Reaction Engines Ltd. could potentially lead to a high-speed, rapid-response surveillance or strike aircraft.

BAE SYSTEMS CONCEPT

ers' requirements, and that is what our planning is about.

There appears to be an increasing emphasis on growth in Turkey, where BAE was selected to assist with development of an indigenous fighter. What are the company's Turkish ambitions?

Turkey is a growing market, but it also requires industrial participation. We have been there for 25 years in our joint venture, FNSS (Defense Systems), which is seen as a Turkish asset and is the country's largest defense exporter, and they are very proud of this. Nurol is our partner there, so we have a good working relationship, and this is an expanding business.

What we are trying to do is form a relationship with Turkish Aerospace Industries, but they will be the national lead, and our relationship will be as a subcontractor. It is valuable in terms of application of our skill sets. We are not a prime contractor, but we are supporting them in contract studies to define what we can do for them. I am hopeful, but Turkey has challenges of its own.

Last year, BAE Systems invested in Reaction Engines Ltd. Are you keen to get back into the space sector?

There are opportunities to use [Reaction's] Sabre engine technology across a range of applications. It could be applied to our core business and may be potentially useful in unmanned. It is a new form of jet engine and has space applications as well. We can add our systems-engineering expertise and prime contracting capabilities to something that is technology-driven, and there is quite a synergy between the organizations. It is likely to find a commercial use first, but from a BAE Systems perspective, we do not see ourselves getting back into providing payloads in the commercial space sector.

Beyond Turkey, what other markets are you looking at?

We have one successful line in India with the Hawk trainer, but we also have ambitions of selling the M777 howitzer. Our relationship with Hindustan Aeronautics Ltd. (HAL) goes back 70 years. We have other aspirations, and once you are in there, you are a credible supplier. We are working on an advanced Hawk that would be a collaboration with HAL. We are looking at a technology demonstrator. It is a combination of work by both of us, with the majority being done by us at the moment as the Hawk's design authority.

Typhoon is a highly supportable equipment set, and the U.K. has committed to the next generation of capability

In 2015, Typhoon production was slowed down to keep the lines warm in anticipation of additional orders. Will those orders still come?

When we slowed down Typhoon production, it was in recognition of the timing of future contracts and to make sure we had a continuous production line to be able to bid and build for those programs.

Typhoon is a highly supportable equipment set, and the U.K. has committed to the next generation of capability in terms of the weapons fit, radar fit and 2040 out-of-service date, all of which bolsters other nations' confidence that it will be continuously upgraded into the future. Our plans have not changed in terms of the quantity of aircraft we expect to sell. There are a number of opportunities around the world, so we are still confident about selling Typhoon aircraft internationally. We will still be producing them in the 2020s and hopefully still selling them.

And what about Hawk?

Hawk continues to sell, because where there is a next generation of fighters, you have to continually upgrade your training capability. We have sold 1,000 of these globally, and we are in a definition phase with customers—do they want to go through an upgrade or go through a replacement? So it is going to continue for some time. And we have longer-term aspirations: There is still a program with Northrop Grumman in the U.S., with T-X, and a lot of that is based on Hawk technology. We have a substantive workshare, and there are parts of it that would be built in the U.K. if we are successful.

Oh, Canada

Long-postponed fighter choice has key manufacturers on edge

James Drew Washington and Lara Seligman RAF Fairford and Farnborough, England

Some 28 years after accepting its last CF-18 from McDonnell Douglas, Canada still has no firm plan for replacing the battle-worn Hornet, even as its loveless relationship with the Lockheed Martin F-35 endures.

After rising to power last November on a platform that included breaking with the F-35, the new Liberal government in Ottawa appears reluctant to depart from the international program the country has supported since 1997, as a nervous industrial base calculates the financial cost of a Canadian F-35 exit.

With important shipbuilding contracts up for grabs at the naval shipyards in Halifax, Nova Scotia, Lockheed—the world's largest defense contractor—wants to avoid any "scorched earth" comparisons. But officials attending the Farnborough International Airshow stressed that if the government reneges on its planned buy of 65 stealthy A-model warplanes, work currently performed in Canada could be outsourced to other, more loyal, program partners and Foreign Military Sales customers.

ROYAL CANADIAN AIR FORCE

A CF-18 Hornet refuels from a C-130 Hercules aircraft during Exercise Maple Flag on June 21, in the sky over 4 Wing Cold Lake CFB, Alberta.

The previous government assessed a range of alternative platforms after concerns were raised about the delayed and over-budget F-35, since it held no formal competition before choosing the Lightning II as its preferred CF-18 replacement. As part of a "seven-point plan" for coming to a decision on CF-X, officials looked at the Boeing F/A-18 Super Hornet, Dassault Aviation Rafale, Eurofighter Typhoon and Lockheed F-35. Saab declined to participate.

Prime Minister Justin Trudeau's government has not solidified its acquisition plan or decided whether to initiate a traditional fighter competition. The new government tells Aviation Week that it will meet with government representatives from the Australia, Denmark, France, Germany, Sweden and U.S. as well as fighter manufacturers as it weighs its choice. A decision is expected in the coming months.

The new government has flirted with the idea of buying F/A-18 Super Hornets as an interim solution, which suggests it might take the Australian route by buying aircraft with provisions and wiring for conversion later into Boeing EA-18G Growler electronic-warfare aircraft. Trudeau has been silent about the F-35 since assuming his post and has sidestepped questions about if or when Canada would leave the program.

No matter what fighter aircraft is selected, Canadian Defense Minister Harjit Sajjan wants any deal to include local jobs for skilled laborers as well as high-end technology.

Jeff Babione, Lockheed's F-35 vice president and general manager, says he is confident the Joint Strike Fighter (JSF) will trounce any rival, as it recently did in Denmark. However, if Canada opts for a stopgap Super Hornet buy, he does not see the country's industrial participation continuing at today's level.

Fifteen years after Lockheed was selected to develop the F-35, Canada has not put money down for a single airplane, although it remains a bill-paying member of the JSF program writ large. But in light of the possibility of the country exiting from the program, Lockheed is actively looking at how long it would take another supplier to assume the F-35 work now performed in Canada, Babione says.

"There is a time line where we might have to take a look and say, 'someone else could do that work,'" tapping in a partner that actually is buying airplanes, Babione said at the Royal International Air Tattoo in the U.K., where the F-35 made its international debut.

Lockheed notes on its F-35 website that Canadian firms have already secured more than $750 million in contracts related to the F-35 program across 200 projects, which is "more than double Canada's current investment in the F-35 program."

Lockheed President/CEO Marillyn Hewson says losing 65 orders would not substantially affect the price, and industry remains committed to driving down the F-35A unit cost to $85 million by 2019.

Lockheed Martin Aeronautics Vice President Orlando Carvalho tells Aviation Week his team is in the process of answering a questionnaire Canada provided to all the potential bidders. He says his company will coordinate with the F-35 Joint Program Office (JPO) on any workshare adjustments, should Canada decide to abandon ship.

Pentagon acquisition chief Frank Kendall says it is up to the prime contractor Lockheed, and not the F-35 JPO, to figure out how the workshare will be divided if Ottawa exits.

"We will have to deal with that as the situation arises," he says. "I think there would be a pretty strong reaction among the rest of the partners to continuing to provide workshare to a country that's not participating in buying aircraft."

The Pentagon has no standard process in place to deal with one partner withdrawing from the program, but future contracts with Canadian industry would likely be up in the air, Kendall says. "I don't think we would stop any existing work that's in place; we're not going to cancel any contracts as far as I'm concerned that are ongoing," he says.

At stake for Canada in its CF-18 replacement endeavor is more than just an aircraft, it is credibility. Trudeau promised a thorough and decisive source-selection decision—long-awaited by the Royal Canadian Air Force, which is struggling to keep its aircraft mission-capable and is already falling behind on its commitments to NORAD and NATO.

Sajjan says just half of the nation's 77 Hornets delivered in 1982-88 are available for combat use at any one time.

This means Canada will be less ready to support coalition contingency operations abroad and will depend more on U.S. goodwill and airpower to protect its eastern and western approaches, just as Western relations with Russia sour.

Time to Split?

Separating military satellite payloads could further allied compatibility

Warren Ferster Washington

An upcoming decision on whether to break up the payload set currently aboard the U.S. military's most secure communications satellites could go a long way toward determining the future of allied interoperability in this area, a senior U.S. Defense Department official says.

Interoperability is most easily achieved when established as a requirement in a program's early stages, says Douglas Loverro, U.S. deputy assistant secretary of defense for space policy. With the U.S. and its closest allies preparing to spend more on their respective military satellite communications fleets in the next decade, there is an opportunity to cultivate greater compatibility across these systems.

"That is going to provide a much better capability than anything we could do individually, or if we share after the fact," Loverro said at the MilSatCom USA conference in Arlington, Virginia, organized by the SMi Group of London, on June 28-29. "So I would urge us all to commit to that goal, to create a unified satellite communications system" by about 2025, he adds.

One of the best ways to achieve interoperability is in the design of satellite ground systems, Loverro says. Allied militaries could take a page from commercial satellite operators' book and build a ground architecture able to accommodate satellites built by different manufacturers, he says.

Loverro specifically identified protected satellite communications as potentially ripe for compatibility. The U.S. Air Force's current-generation Advanced Extremely High Frequency (AEHF) satellites, still in production, carry two main payloads: a strategic one that enables the national command authority, led by the president, to execute nuclear war plans; and a secure one to support nonnuclear, or tactical, operations.

The U.S. military is weighing whether to launch these payloads on separate satellites in the future, with a decision expected before year-end, Loverro says. Should the Pentagon elect to fly them individually, the tactical satellites could be closely integrated with comparable allied capabilities, he says.

"It is really hard for any of us to share strategic communications that deal with the command and control of our most sensitive capabilities," Loverro says. "And the use of protected strategic communications has some requirements that are not the same as [those] for tactical communications; they need to work during a nuclear war."

Those requirements, he says, are far more rigorous, difficult and expensive than for secure tactical communications. Moreover, because U.S. authorities are loath to introduce any risk into its nuclear command-and-control capabilities, the strategic mission tends to resist even evolutionary changes, he adds.

The tactical mission, on the other hand, lends itself to allied and commercial cooperation as well as evolution.

Loverro says that while he personally favors disaggregating AEHF, the matter has not been decided. He noted there are concerns within the Pentagon about separating the missions but did not specify what those were.

Should the disaggregation occur, there will be ample opportunities for allied collaboration on the tactical mission, including joint development and hosting of U.S.-supplied tactical payloads on commercial or allied satellites, Loverro says.

Many in industry remain skeptical, both about disaggregating AEHF and closer interoperability in general. Loverro acknowledges as much, saying sovereignty issues—even close allies typically resist relinquishing control of critical capabilities—and industrial base considerations often get in the way.

LOCKHEED MARTIN

By the end of 2016, the U.S. military is expected to decide on its plan to replace the current generation of Advanced Extremely High Frequency satellites, which are still in production.

In the past, interoperability has all to often meant buying U.S. equipment, which creates an additional a financial burden for allies without necessarily benefiting their industries or enhancing their technological capabilities.

Cmdr. Jean-Philippe Vautier, satellite communications program officer at the French Joint Space Command, says opportunities to cooperate may emerge in the near and mid-term in protected communications. In the long term, however, France will want to develop this technology for itself.

Meanwhile, Lockheed Martin Space Systems and Northrop Grumman Aerospace Systems, the two main industrial contractors on the AEHF satellite program, are leading development of a low-cost AEHF terminal that could pave the way for interoperability in the near term. The terminal, developed with corporate funding, is designed for exportability and affordability, says Mark Schwene, director of advanced satellite communications at Northrop Grumman.

It would be manufactured by Comtech TCS of Annapolis, Maryland, Schwene says, adding that the target cost for production versions is under $500,000. That price would overcome a long-standing barrier to closer allied cooperation on the AEHF program, he adds.

Loverro points out that the U.S. does not have a monopoly on protected communications technology, and that realizing interoperability is primarily a matter of will.

"It's not a matter of, 'Can it work?' it's a matter of, 'Do we want it to work?' " he says. "If we want to make it work, it will."

SEP Shift?

Mars orbiter in 2022 may be backup for solar-electric propulsion demo

Frank Morring, Jr. Washington

Officially, NASA considers the near-Earth asteroid designated "2008 EVS" as its "reference target" for a robotic sampling mission scheduled in 2021 that would demonstrate the solar electric propulsion (SEP) technology it will need to take humans to Mars. Unofficially, Mars is a more likely target for a SEP demonstration, with launch a year later.

As is so often the case lately with the U.S. space program, partisan politics will drive the ultimate decision. The Asteroid Redirect Mission (ARM) is an offshoot of President Barack Obama's 2010 call for a human asteroid probe. Congressional Republicans want no part of it.

With the resolution probably riding on the outcome of the Nov. 8 elections, engineers working on the SEP system for the asteroid effort are pressing to keep it flexible enough to handle both the ARM and a Mars orbiter under study for the planetary launch window in 2022 that could also use the technology.

"From our perspective, what we are trying to do is say to them, 'Do not focus it down so narrowly that if it changes to a different demonstration mission, we are locked into something we have to go back and undo,'" says Joe Cassady, an electric-propulsion engineer who handles spaceflight business in Aerojet Rocketdyne's Washington office. "And the other thing is we want this to be extensible. This is our development program for the Mars cargo vehicle."

Mars is the ultimate destination for NASA's human space exploration program, and humans cannot operate there without the large habitats and heavy cargo loads that engineers believe SEP can deliver. When Obama's proposed human asteroid visit was descoped to a robotic mission, exploration managers at the agency considered it an excellent technology "pull" for the high-power SEP they want for transporting 20-ton loads to Mars.

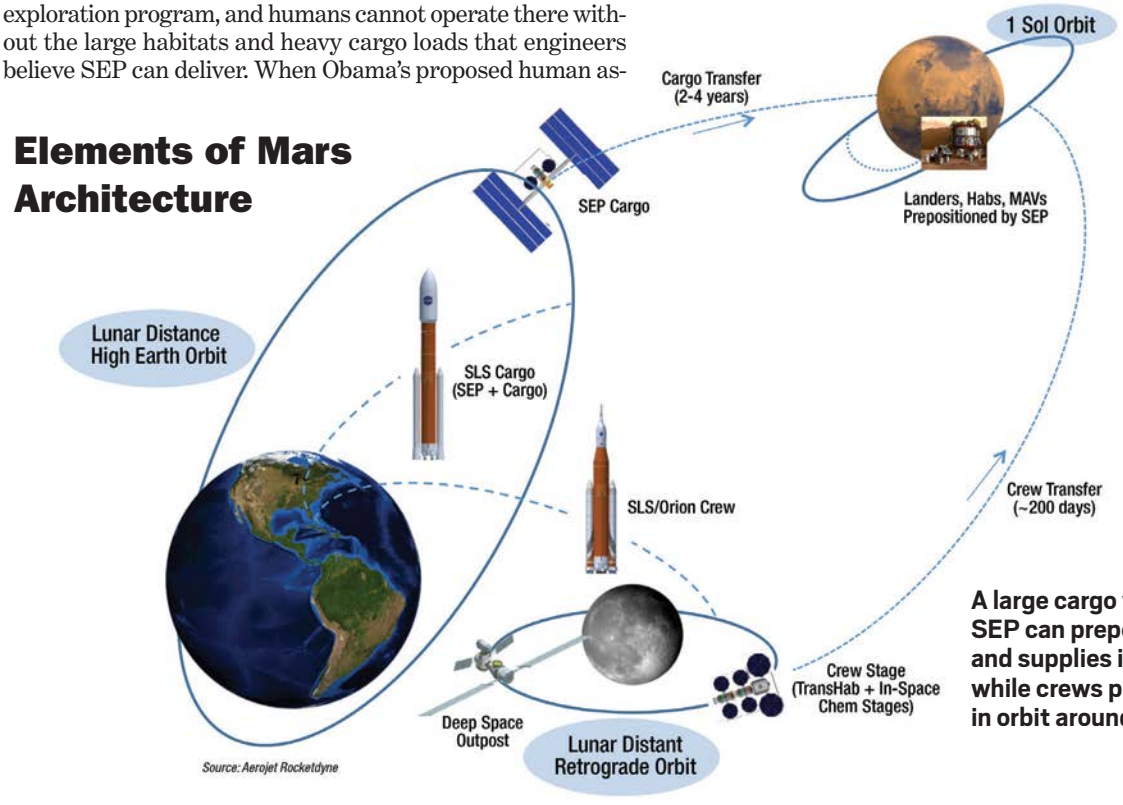
The asteroid project has gotten the ball rolling—Aerojet Rocketdyne is in the early stages of a three-year, $67 million contract to develop an advanced SEP system that would deliver the unmanned ARM spacecraft to pluck a boulder from 2008 EVS for later analysis by astronauts orbiting the Moon. But the Republican-led House Appropriations Committee explicitly forbids NASA to spend money in fiscal 2017 "to continue planning efforts to conduct either robotic or crewed missions to an asteroid."

Congressional objections do not extend to SEP, which retains bipartisan support as a promising solution to the Mars-exploration problem. And NASA has a fallback in a 2022 Mars orbiter that could exert the same technology pull for SEP upgrades as a visit to an asteroid.

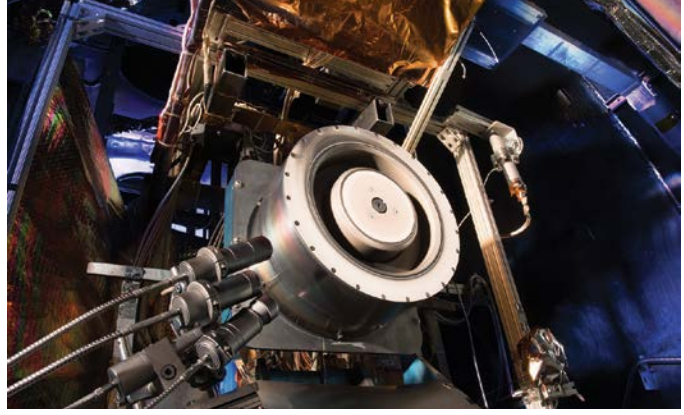
"With solar electric you have a very efficient way of getting that bird out there," says Rick Davis, assistant director for science and exploration in NASA's Science Mission Directorate. "It can be bigger than what we have done previously. And even more important, when the satellite arrives at Mars, it has abundant power—which we have always been short of in the Mars exploration program—because we are not using it for thrusters anymore."

Davis says he acts as a bridge between the science and human-exploration directorates at NASA. The growing understanding that the dry dusty surface of Mars may conceal substantial deposits of water ice that could be used by astronauts for life support, energy and propellant is driving a push to place a ground-penetrating synthetic aperture radar in Mars orbit to look for that ice, he says.

"What we can do is take that power and redirect it to a



A large cargo vehicle driven by SEP can preposition habitats and supplies in Mars orbit, while crews prepare for the trip in orbit around the Moon.



NASA

Aerojet Rocketdyne is building on this 13-kW Hall thruster, tested at NASA's Glenn Research Center, to develop a SEP module for spaceflight applications that range from Earth orbit to Mars.

radar system, potentially, and really find out where the near-surface water deposits are, which we know are significant at Mars, but we have not been able to get the right radars there previously," Davis told a Washington audience at the annual Humans to Mars Summit in May.

Nothing really needs to be invented for that to happen: Engineering upgrades to existing technology will suffice. Satellite operators have been using SEP to keep their geosynchronous Earth orbit birds on station for years, and with good reason. Instead of thrusters burning heavy, usually toxic, chemical propellants, it is more efficient to use electricity to ionize and accelerate propellants such as xenon to produce thrust in space.

The thrust generated by an SEP system is much weaker than that of a traditional chemical thruster, but the significantly higher specific impulse—more than 7,000 sec. in some systems—increases the propellant's efficiency as much as 10 times. That can lower the launch mass correspondingly—an important consideration when you are figuring out how to move a Mars base across almost 40 million miles of open space but are not in a hurry to get it there.

A key element in NASA's "Journey to Mars" strategy involves prepositioning infrastructure on the planet's surface for human crews to use when they arrive. Agency engineers are planning SEP-driven vehicles that would slowly accelerate large cargo vehicles to Mars orbit for eventual deployment on the surface.

NASA has been considering a variety of mission concepts for the 2022 Mars launch opportunity. They include an orbiter that could demonstrate SEP in transit to the planet, continue ongoing remote sensing of the surface, and explore one or both of Mars's two small moons. Agency engineers also have been developing SEP technology to enable the ARM mission, and it is beginning to appear that the two efforts may converge in orbit around Mars.

"Multiple" contract awards for short-term concept studies are due out soon. The initial orbiter idea—dubbed NeMO for Next Mars Orbiter—would carry a pair of SEP systems using the "gridded ion" approach. Ions are generated from the xenon propellant by an electric charge and then accelerated by passing them through two or more charged grids to produce thrust.

NeMO would use 20-kW solar arrays to power a single ion engine and carry a spare SEP system in case the primary fails. It could be used to place a high-resolution imager and a communications relay over the planet, to supplement the aging infrastructure in orbit there.

Meanwhile, the ARM mission has baselined Hall-effect thrusters as its SEP system, with more power than the gridded ion systems planned for NeMO. Hall thrusters use magnetic forces to accelerate the ions, which permits designs that can prolong system service life past the timescales needed for deep-space missions.

The charged ions flowing out of electric propulsion systems can erode the spacecraft surfaces they touch, a factor system designers must carefully manage to prevent damage that shortens service life. In gridded ion systems, that is usually accomplished by adding charges with the needed polarity to deflect the charged particles. To that same end, experts at Glenn Research Center in Cleveland, the focus of NASA's electric propulsion work, have developed and ground-tested a magnetically shielded Hall thruster rated at 13 kW (see photo).

"You use magnetic forces to accelerate them anyway, so what you do is tailor that field so that they are accelerated in such a way that they stay away from the walls of the chamber," says Michael Barrett, an electric propulsion research and development engineer at Glenn.

Aerojet Rocketdyne is modifying that design for a lightweight system that can be flown, with ARM as the baseline mission. Cassady says ongoing discussions between NASA and his company have centered on meeting the specific needs of the asteroid mission with a "modular" system that can serve other purposes as well, including a Mars orbiter with a powerful ground-penetrating radar.

"If you do it right, and have that whole power and propulsion system as a sort of module, then you can essentially have a separate mission module that is the avionics and control, and that can be tailored to whatever you need," he says. "You can do Earth-orbit raising with one type, and deep space missions with [another], but you do not have to change that fundamental building block with the power and propulsion."

The ARM baseline robotic mission carries a 50-kW solar array to power SEP in the 40-kW range. The notional system would have three 15-kW units, plus a spare, to carry the robotic spacecraft out to 2008 EVS, collect a boulder, conduct some "gravity tractor" experiments with it, and then bring it back to lunar orbit for eventual study by astronauts arriving in an Orion crew capsule (*AW&ST* Jan. 25-Feb. 1, p. 38).

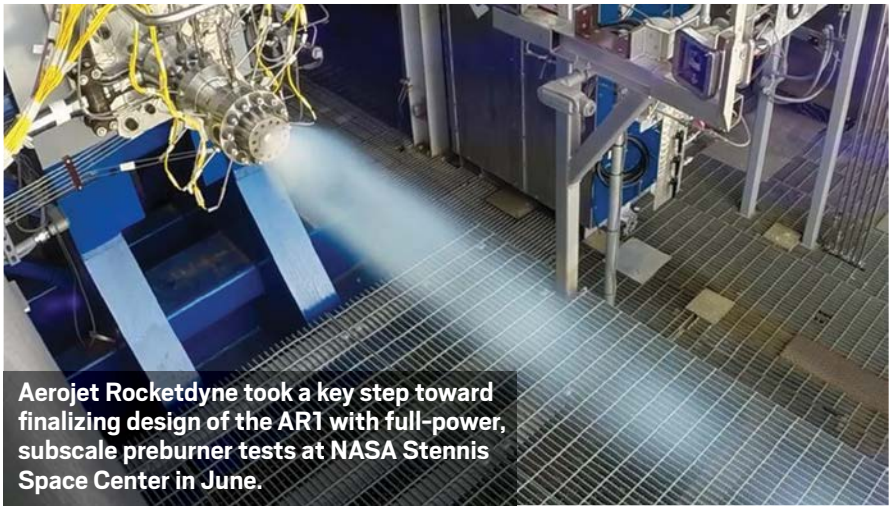
More power would probably be needed to transport heavy loads to Mars rapidly enough to preposition them for the human crews following along. In one architecture, a heavy-lift Space Launch System (SLS) would deliver cargo to a Lunar Distance High Earth Orbit, with an apogee approximately as far from Earth as the Moon and a perigee in low Earth orbit. From there, a SEP-driven cargo vehicle would take it on a 2-4 year journey to Mars, where it would be inserted into an orbit with a period of one sol, or Martian day.

A crew would follow in a habitat delivered from the same Lunar Distant Retrograde Orbit planned as the ultimate destination of the ARM spacecraft, transferring to the habitat from an Orion crew vehicle launched on an SLS. At Mars, the crew would descend in a lander, or remain in orbit teleoperating rovers and in situ resource utilization gear to continue building up the surface infrastructure and store locally produced propellant for the Mars ascent vehicles (MAV) needed for return trips (see illustration on page 48).

"That sets things like how big a SEP do we have to have" says Cassady. "Is it going to be a 150-kW vehicle or a 200-kW vehicle? We would like to keep it as low-power as we can for that cargo vehicle, from an affordability consideration. It also makes it easier to take the 50-kW demonstration and scale it up to that. Our goal is to make it a one-pass development, and then have it on the shelf for the cargo."

Rocket Reinvention

Manufacturing drive for traditional space reflects Aerojet Rocketdyne's broader bid for 'new space'



AEROJET ROCKETDYNE

Aerojet Rocketdyne took a key step toward finalizing design of the AR1 with full-power, subscale preburner tests at NASA Stennis Space Center in June.

Guy Norris Los Angeles

As Aerojet Rocketdyne marks completion of another key component test of the AR1, its engine contender for future U.S. national security launchers and other vehicles, the rocket maker is weighing manufacturing and design initiatives related to "new space" projects in its bid to cut costs and open up new markets.

With roots reaching back to the start of the space age, Aerojet Rocketdyne is fully aware that even without fierce competition from startups such as Blue Origin and SpaceX the time for reinvention is now. Although this principle is being applied across the board—from lunar lander projects and in-space propulsion to heavy thrust engines—the immediate focus for the U.S. rocket-engine house is the contest to power the main and upper stages of the United Launch Alliance (ULA) Vulcan.

Intended to succeed the Atlas V and Delta IV, the Vulcan will be powered by U.S.-developed engines in a move to end reliance on Russian-made RD-180 rockets to launch U.S. military and intelligence payloads. A derivative of Aerojet Rocketdyne's RL10 is one of the contenders for the Vulcan's Advanced Cryogenic Evolved Stage (ACES) upper stage, while the company's AR1 main-stage engine is in a race against Blue Origin's BE-4, the liquefied natural gas-fueled engine selected by ULA as the preferred solution for the first stage (*AW&ST* April 11-24, p. 50).

Aerojet Rocketdyne is pulling out all the stops to slash costs and advance quickly through the test program, which is targeted at producing fully qualified engines in 2019. "The technology is here, the manufacturing approaches are here," says Jim Simpson, the company's senior vice president of strategy and business development. "That's the path we are taking. We all recognize that if your costs don't go down, then you're not going to be competitive in the future and you're not going to be a viable business." He notes that the company is investing heavily toward that end.

While distinguishing between the "conventional" space world of large engines and launch vehicles for national security payloads and the emerging "new space" market of low-cost satellites and launch systems, Simpson says there are lessons to be learned that benefit both sides. "We are doing things in the new space arena right now. Arguably, using additive manufacturing (AM) is one key to enable the cost point that new space is going to require." Design initiatives and lower manufacturing concepts devised for new space are now being applied equally to the latest mainstream space projects.

Speaking to Aviation Week on the sidelines of the Space Frontier Foundation's NewSpace Conference in Seattle last month, Simpson said the recent completion of a full-power test of the AR1 preburner at NASA Stennis Space Center is a testament to the success of the company's revised design and manufacturing approach. The test, which was completed in June and conducted at 40,000 lb. thrust, verified key preburner injector design parameters and underscored that the company is on track to meet its critical design review at year-end, he said. The evaluations at Stennis are a continuation of earlier preburner testing at NASA's Marshall Space Flight Center and the company's Sacramento, California, facilities.

"With AR1, we'd like to get the economics down, and we are. [The engine] costs substantially less than the RD-180" and has a similar performance, he added. Even though the 500,000-lb.-thrust, kerosene-fueled engine comprises a shipset of two engines to equate to the RD-180, this is "less expensive, and with very similar internal pressures," he said. "The design was developed to be the easiest way to transition from the RD-180 with the least amount of changes to the booster. There is also the question of timing and the urgency of how we get off the requirements for a Russian engine as quickly as possible, have a replacement available for the 2019 time frame and have it be proven in flight," Simpson said.

For the RL10C-1 engine variant aimed at ACES, Aerojet Rocketdyne says it has had early success in significantly reducing costs by using AM. "We are actually building critical elements of the vehicle that will allow cost to be reduced substantially," said Simpson. "The objective is to be able to get the cost of the RL10 down by at least half and maybe more, and part of the target is to make the cost of ACES go down by reducing the cost of engine testing," he added. The focus has been on hot-fire tests of the RL10 development engine configured with a core main injector built using a selective laser melting (SLM) additive manufacturing process. SLM is also being used to make a thrust chamber assembly from copper alloy.

From a broader perspective, the new space market is already stimulating development in electric propulsion and green propellants. As to efficiently transporting payloads to space with lightweight satellite systems, Simpson said: "Electric propulsion is an approach that reduces the quantity of fuel required by a factor of 10 in some cases.

For every pound of fuel saved, a pound of payload [can be added]."

While most of the potential new space applications will be about 5-kW or less, related but far more powerful electric propulsion work is underway as part of a $2.5 million NASA Advanced Exploration Systems Division contract. The work, awarded earlier this year, covers development and demonstration of a high-power system that could be used to reduce trip times and the cost of human spaceflight to cislunar space and Mars. Key targets include development of a 100-kW Hall Thruster System, including a 250-kW thruster that uses the company's multichannel Nested Hall Thruster technology.

The contract also covers development of key elements of a 100-kW modular power processing unit, which converts electric power generated by solar arrays into power needed for the spacecraft's Hall Thruster. Associated work will focus on development of portions of the modular xenon feed system. "Instead of traditional chemical thrusters for station keeping and moving to transfer orbits, we see great advantages with electric propulsion and particularly the efficiency of the xenon fuel. The specific impulse [I_{sp}] of the xenon in Hall effect thrusters is about 3,000 sec. For a typical chemical thruster it is more like 400 sec., so electric propulsion offers great efficiencies," he added.

"We are also looking at different fuels for green propellants. Assuming new space occurs and we get to blot out the Sun with satellites, we are making sure the fuels are not hurting the environment," said Simpson, referring to the company's involvement in NASA's Green Propellant Infusion Mission (GPIM). This is set to launch from Cape Canaveral AFS around March 2017 aboard SpaceX's Falcon Heavy rocket as part of the U.S. Air Force's Space Test Program 2 mission.

Aerojet Rocketdyne provided the green monopropellant propulsion system for the Ball Aerospace-built BCP 100 spacecraft that will be used to test the propellant in GPIM. Developed by the Edwards AFB branch of the Air Force Research Laboratory, the hydroxyl ammonium nitrate fuel/oxidizer mix—AF-M315E—is designed to be both safer and more efficient than standard hydrazine. GPIM will be the first flight for the new propellant, which is about twice as dense as hydrazine and has almost 50% higher performance for a given propellant tank volume compared to a conventional system. Following deployment from the Falcon Heavy, the spacecraft will conduct tests of the propellant for in-space attitude control as well as primary propulsion using both of the vehicle's 0.2-lb. and 5-lb. thrusters.

Another new space project, involving the company's ISE-100 engine, is the Astrobotic Peregrine Lander, which is among the current frontrunners for the Google Lunar X-Prize aimed at delivering a rover to the Moon. "We are pursuing commercial lunar delivery for the project, so we are doing some far-reaching things," said Simpson.

Virgin Launcher

Long Beach rocket factory gets busy as LauncherOne development steps up

Guy Norris Los Angeles

More than a year after radically changing course and scaling up to a larger satellite launch vehicle for broader market coverage, Virgin Galactic is on track to begin flight tests of its more capable LauncherOne in 2017.

The two-stage rocket is in the vanguard of a new generation of air-launched systems aimed at dramatically cutting the cost of access to space for smaller payloads. For Virgin Galactic, which announced it was moving forward with LauncherOne in 2012 as an adjunct to the SpaceShipTwo (SS2) suborbital spaceline venture, the project has kick-started the creation of new, vertically integrated, rocket development and manufacturing capabilities in California.

The focus for development work is at Long Beach, where Virgin's engines and launch vehicle are in design and build phases. Testing of LauncherOne's Newton rocket engines continues at Mojave, in the high desert north of Los Angeles, where some facilities are shared with the company's SS2 project. Meanwhile, modifications to convert former Virgin Atlantic Airways Boeing 747-400 "Cosmic Girl" into a carrier for air-launching the vehicle continue at L-3 Platform Integration in Waco, Texas.

GUY NORRIS/AW&ST

Virgin Galactic's Cosmic Girl, formerly a passenger-carrying 747-400, is pictured along with a model showing how it will look after conversion into its space launch configuration, underway at L-3 in Waco, Texas.

"We are very happy with the testing so far," says Will Pomerantz, vice president of special projects at Virgin Galactic. "We began the LauncherOne program by working on the Newton engines first because that is the hardest single problem, and it is also the problem we have been going at the longest." Two derivatives of the same baseline, liquid oxygen/kerosene-fueled rockets are in development for the two-stage vehicle. The first-stage NewtonThree (N3) engine is rated at 73,500 lb. thrust, while the second-stage NewtownFour (N4) will have a vacuum thrust of 5,000 lb.

The N3 and N4 are derived from earlier, lower-thrust, pressure-fed NewtonOne and Two engines that were rated at 3,500 lb. and 47,500 lb. thrust, respectively. The move to the N3 and N4 reflects Virgin's 2015 decision to double payload capability to 200 kg (440 lb.) to sun-synchronous orbit (SSO) and build a bigger rocket. Both engines are now fed by turbopumps and make up a stack, with fuel and payload weighing just under 60,000 lb. This also resulted in Virgin changing launch platforms from the SS2's White-

VIRGIN GALACTIC

Virgin Galactic's 150,000-ft.^{2} shop floor at Long Beach is sized for production of up to 24 LauncherOne vehicles per year.

KnightTwo mother ship to the 747.

"We are pretty far along, and now we have tested the turbopump assemblies as well as the full engine, particularly the N3," says Pomerantz. "We are not as far along with the N4. The N3 is the harder one, and there is as much similarity as was practical to design between them. The thrust chamber, injector and turbopumps are all similar, with just a difference in scaling factor," he adds.

The entire design and build of the engines is done in Long Beach, with the exception of the turbopump assembly, which is made by partners Barber-Nichols. That Arvada, Colorado-based company is a turbo-machinery specialist that entered the space launch industry in 1996, when it teamed with NASA to design and build the turbopump for the low-cost booster Fastrac engine. The company also teamed with Rocketdyne on the Bantam engine and more recently designed and produced the turbopump for SpaceX's Merlin engine.

"Basically, the rest of it happens in Long Beach, where we are putting a lot of emphasis into advanced manufacturing techniques, such as additive manufacturing," says Pomerantz. "I think we have some special sauce that will allow us to do some things better, or at least cheaper, than other folks in the industry for printing rocket engine parts," he adds. Virgin has been keen to emphasize that, despite doubling payload capability and even offering dedicated missions that can loft up to 300 kg to SSO, the target price point for each mission remains under $10 million.

This capability comes partly from advances in manufacturing, particularly in composites that form the vehicle's structure, including the fuel and oxidizer tanks, as well as a simple overall design philosophy. "As a general rule, on LauncherOne we have tried to avoid science projects. Recognizing that this is the first project that we have done entirely in-house, rather than outsourcing, we did not leap all the way to the most exotic propellants and so on," says Pomerantz. "This is particularly because of our value proposition to our customers. They want to use LauncherOne because it is cheap, we will build a lot of them and it is flexible. So we said we will do science projects if it helps us in one of those three areas. We might do them some day, but other than that the idea is to keep it simple.

"N3 and N4, at a broad level, by intention are relatively simple engines for what they are," he adds. "In the few areas where we have done science projects, [they relate to] manufacturing systems and avionics, the latter including development of an autonomous flight safety system. The last one is the manufacturing system for the all-composite structures, particularly the composite tanks."

Despite the gradual adoption of carbon composites for launch vehicles, including the success of companies such as Rocket Lab—which has developed the Electron rocket almost completely from the material—the validation of lightweight composite structures is critical to Virgin's business plan. "We are super happy with that and that is a big relief. It makes a big difference in how much payload we can carry to orbit; it drives [much of] the profitability of the system, as well as driving build time for individual rockets to come off the line," says Pomerantz.

The use of composites therefore underpins "the capability to build many of these and fly twice a month, or whatever the market demands, and be able to reduce the build time for critical parts," he adds. The use of the material is "one of the relatively few areas where, instead of taking what others have done and make it cheaper, we are doing what others have not done before. It is exciting, and it is nice to have a few of those."

From the engine test perspective, "there is still plenty of work to be done," says Pomerantz. "We have to fire for longer durations and so on, but we have fired the NewtonThree engine for 90-plus sec., which is ballpark for about half of a mission duty cycle." The test run was limited only by the size of the fuel/oxidizer tanks on the Mojave test stand, he adds. The results were encouraging, as the engine hit steady-state operations within seconds of ignition and ran without change until the fuel was exhausted.

Orbital test flights are on track to begin in 2017 with initial operational flights targeted for early 2018. "In early operations, Cosmic Girl will live in Mojave, so we will ship fully built, dry [unfueled] rockets there, do the integration and fly out over the Pacific for launch. In the relatively early operations, we will also do East Coast launches, because we have some customers looking at different inclinations," he says.

The market itself is "doing well," says Pomerantz. "We have signed a few new customers and are seeing a lot of demand. Most are buying multiple launches and want a regular cadence of one or two per year. Most of our customers want constellations—which is the whole point—so from a business perspective it's great dealing with single customers with similar payloads over and over again. You are only doing the analysis once and that makes it faster and cheaper."

In preparation for the busy years ahead, Virgin's Long Beach facility is sized to support a maximum of 24 vehicles per year. "We moved into a deliberately big facility and it is frankly far bigger than we need right now," says Pomerantz. "But we did not want to have to expand later on or have shuttles to connect two sites, with all the inefficiencies that brings," he adds.

Following the Water

Rover will image and perhaps visit Gale sites, seeking liquid water

Frank Morring, Jr. Washington

Mars-rover drivers will aim Curiosity's cameras "soon" at a pair of nearby features spotted from orbit where liquid water might flow sporadically, and they may send their nuclear-powered robot there on a visit one day to hasten the search for extraterrestrial life.

Curiosity (see photo below) is nearing a point on the side of the central peak in Gale Crater that offers a view of at least two gullies that may be recurring slope lineae (RSL). This type of feature is widespread on Mars; planetary scientists now believe the area can run with briny water when conditions on the surface are warm enough.

"Absolutely," vows Jim Green, head of NASA's Planetary Science Division. "Absolutely. Whenever it gets into position to see it, we're going to look at it."

Green says two small features on the side of the 4-km (2.4-mi.) central mountain popularly known as Mount Sharp (see illustration, page 54) are targets for observation with Curiosity's MastCam camera to determine if they recur, and the cause of the recurrence if they do.

With the best 25-cm (9.8-in.) resolution imagery available from the High-Resolution Imaging Science Experiment (HiRISE) camera on the Mars Reconnaissance Orbiter (MRO) spacecraft—used extensively over Gale Crater in preparation for Curiosity's August 2012 landing—analysts still cannot say for certain that features within range of Curiosity and its camera are RSL. Periodic imaging by the rover may settle the question and help scientists learn more about the presence of water on the sides of Mount Sharp, as well as elsewhere in Gale Crater and across Mars.

"Soon, hopefully within a year, we will be in a position to take higher-resolution images of the area that's purported to be an RSL, at a much higher resolution than that of MRO," says Green, noting that other observations may take precedence along the way. "And then we'd be able to observe it . . . and say, 'no, that's really a dust slide,' or watch it change."

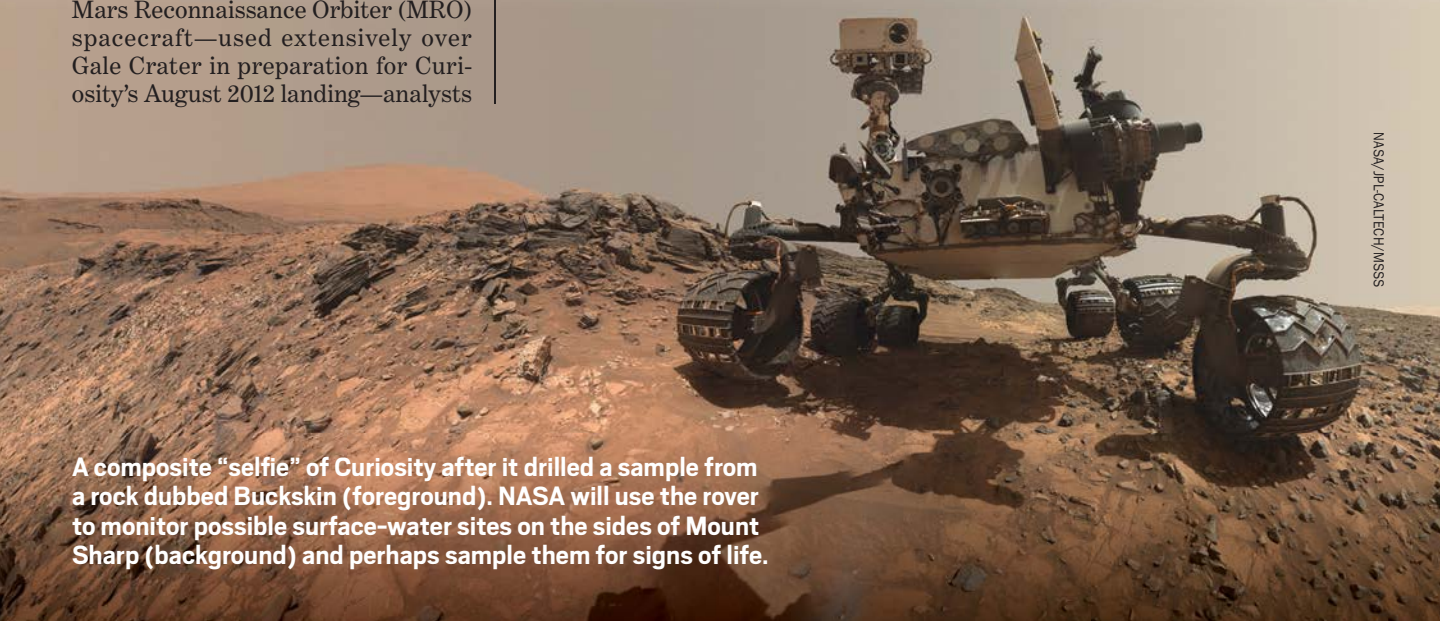
Across the planet, RSL—visible in HiRISE and other overhead imagery—are usually on the sides of craters, valleys and hills facing direct sunlight, and they change over time. That led scientists to suspect they might be caused by running water, perhaps released from salty subsurface ice deposits when temperatures are high enough to melt them. Spectral analysis with the MRO's Compact Reconnaissance Imaging Spectrometer ultimately found hydrated minerals—thin patches of damp soil—in some RSL, boosting the chance they were caused by flowing water.

Aside from the difficulty of reaching RSL on the steep slopes where they typically are found, visiting one with Curiosity also raises planetary protection issues. Astrobiologists worry that terrestrial microbes could ride a spacecraft built on Earth to another celestial body and propagate there under the right conditions. That would confound any subsequent discovery of possible extraterrestrial life.

NASA employs a "planetary protection officer" with responsibility for preventing "forward contamination" with Earth life of other bodies, and "back contamination" of Earth by extraterrestrial life that could prove deadly here. On Mars, RSL are designated "special regions" where extra care must be taken to prevent forward contamination because of the suspected presence of water, which is considered a prerequisite for life.

Green says "a special region is not a keep-out zone" but does need more stringent standards to keep it pristine. He argues that almost four years of exposure to the harsh Martian environment—including ultraviolet radiation and cosmic rays—probably have killed any residual microorganisms that survived the sterilization process Curiosity underwent before launch.

If the Curiosity cameras find that the suspected RSL sites are the real thing and have been formed by flowing water, "then and only then would we go into the extensive analysis necessary to convince the planetary pro-



NASA/JPL-CALTECH/MSSS

A composite "selfie" of Curiosity after it drilled a sample from a rock dubbed Buckskin (foreground). NASA will use the rover to monitor possible surface-water sites on the sides of Mount Sharp (background) and perhaps sample them for signs of life.

tection officer that the environment of Mars has changed the category of Curiosity," Green says. "So it's a given that it has [done so], but what we have to demonstrate is is it enough for the planetary protection officer to be convinced that she can recategorize it to the point of where we could go over to the RSL and taste it?"

The NASA Advisory Council has a planetary protection subcommittee that is overseeing the Gale Crater developments, as is Catharine "Cassie" Conley, a plant biologist who is NASA's current planetary protection officer. She was unavailable for an interview, but John Rummel, a predecessor in the job, says he believes it will be possible to build a spacecraft that can explore an RSL without compromising its biology.

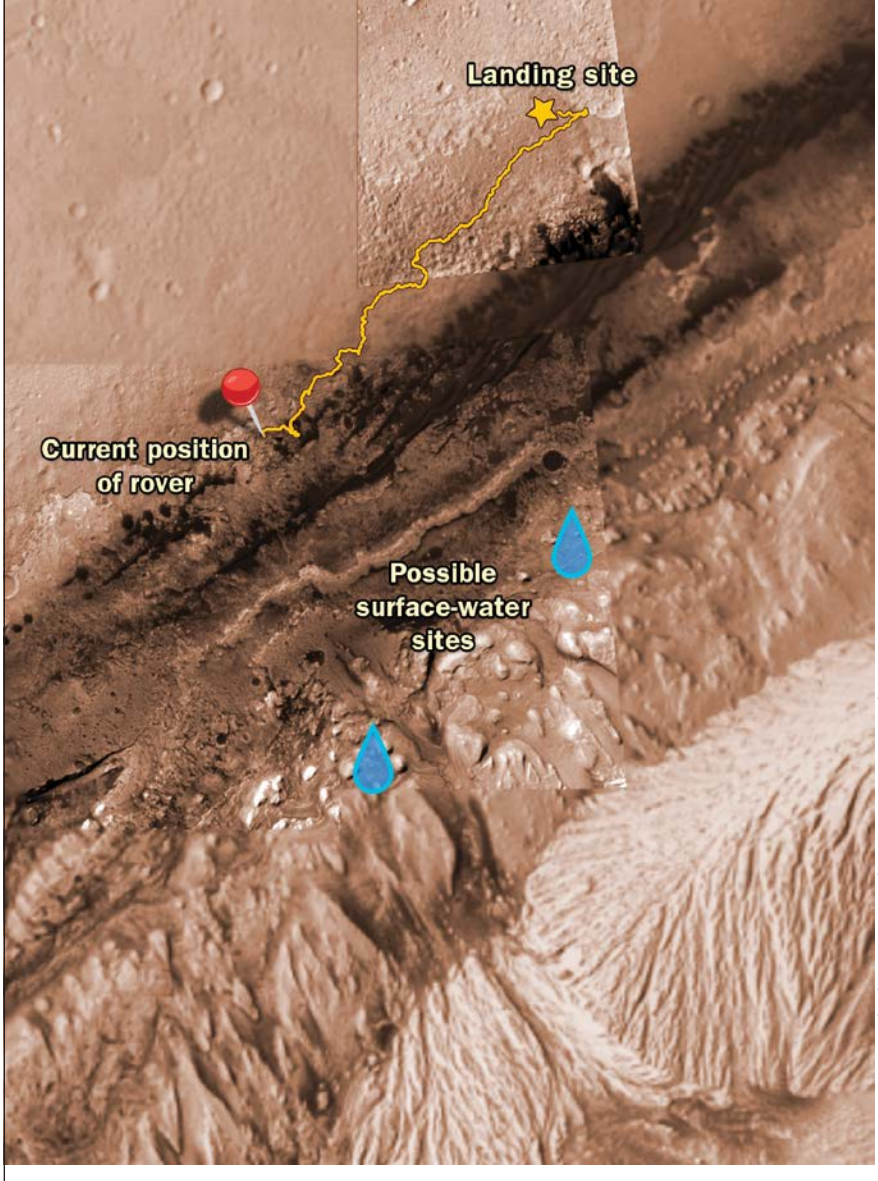
"It just means you have a different level of responsibility for planetary protection, and basically it is a level of protection that goes back to the Viking missions," says Rummel. "[T]here is no place we know of right now on Mars that you couldn't have sent Viking I or Viking II—with your fingers crossed—to say that you could land there safely."

Those 1970s-vintage landers were heat-treated to kill microbes, a process Rummel says spacecraft engineers today are reluctant to repeat, even though U.S. military-standard aerospace components also receive heat-treatments that probably would meet planetary-protection requirements.

Rummel suggests it is less certain that its exposure to the Martian environment has sterilized Curiosity adequately, which could make it more likely that the planned Mars 2020 rover could be cleared instead to work in special regions as it collects and caches samples for eventual return to Earth for analysis.

"You have certain ultraviolet radiations that can be applied to smooth surfaces," he says of sterilization techniques on Earth. "You worry about the roughness of the surface because microbes tend to fill the cracks, and if you put something through at the wrong angle you'll miss some. . . . There are some very good material choices out there that make it easier."

Regardless of the cleanliness of the spacecraft, the Martian environment may be too cold to sustain terrestrial life, even if it sometimes rises above the melting point of the briny water believed to be flowing in RSL.



AW&ST/C.M. DUNDAS, A.S. MCEWEN/ICARUS AND NASA/JPL/UNIVERSITY OF ARIZONA

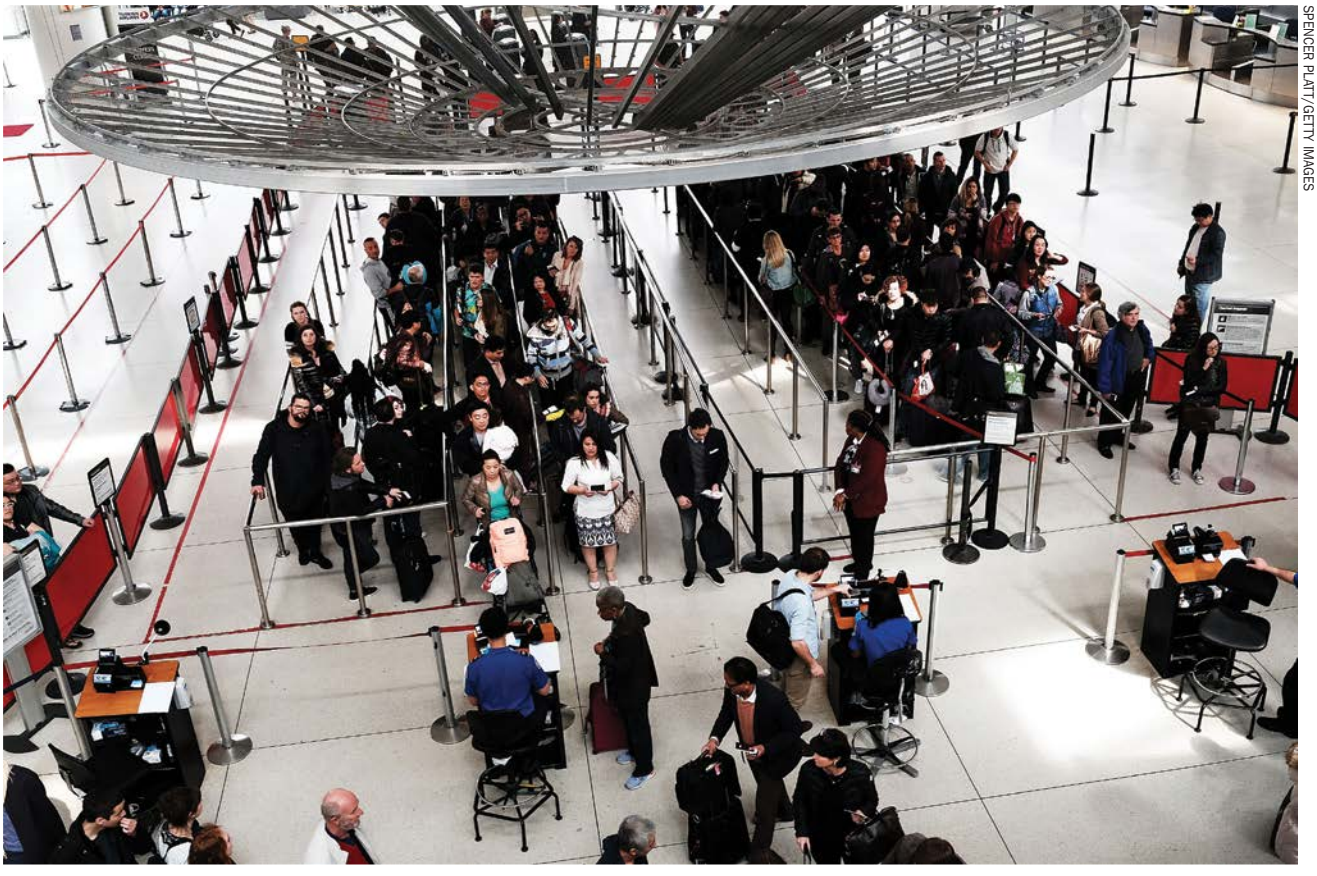
The rover soon will reach a vantage point where it can use its MastCam to image a pair of features that may be recurring slope lineae formed by running water on the surface.

"At a depth of 15 cm and throughout all of the year and at all of the sites visited by Curiosity, the subsurface temperature is below the known temperature requirements for replication and metabolism of terrestrial microbial life forms," states a letter published in *Nature Geoscience* on April 13, 2015, dealing with "Transient liquid water and water activity at Gale Crater on Mars."

Even if analysis determines that Curiosity can safely explore RSL, and if the rover can reach one of them, the data it collects will be only a first step toward establishing whether extraterrestrial life is present. Green says the rover probably first would use its "ChemCam" laser to vaporize a small portion of RSL material and analyze its composition spectrographically. It could also scoop a sample into its internal Sample Analysis at Mars robotic laboratory for analysis.

But as the scientists on Viking learned when their instruments yielded conflicting results on the presence of life, Curiosity will not be able to provide definitive evidence that something extraterrestrial is alive—that it metabolizes nutrients, reproduces and evolves. It was not designed to do that. But it "could give us a positive indication of what we need to do next for another mission down on the surface," says Green.

"Even though Curiosity could give us some really significant information, the concept of whether it's life or not would still be debated because we can't make the measurements that it is a slam dunk it is life," he says. "That is hard to do. But it would be a preponderance of measurements that indicate all positive indications of life."



SPENCER PLATT/GETTY IMAGES

Biometric Ambitions

Rockwell Collins, SITA developing next-generation self-service travel

John Croft Washington

Airports are eyeing the self-service options already available in much of the consumer world as a saving grace for the growing congestion on the ground side of the air passenger travel experience.

Long security lines could be a thing of the past as airports introduce automated self-service systems that rely on passenger biometrics.

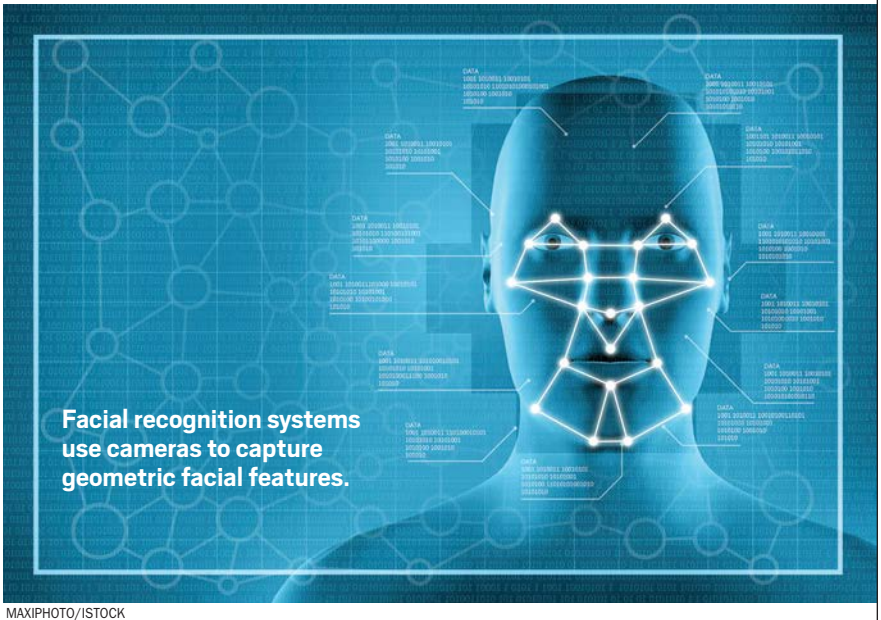
Two major competitors in the airport infrastructure business—Rockwell Collins and SITA—are researching and testing similar yet unique self-service approaches to paperless, biometric-based, secure movement through airports for all travelers. Both caution that the end game—moving unimpeded and quickly from airport entrance to the jetway, and vice versa, across all airports and borders with minimal human intervention and little or no need to display physical travel documents—is a stretch goal. "This vision is many years away," says Renaud Irminger, director of SITA Lab. "To get there, we have to take little steps."

In addition to benefiting passengers—with less hassle and faster airport throughput—airlines will be able to replace workers with automation at international check-ins and bag drops, and government security agencies will be able to redeploy employees from checking documents. "Airlines will achieve savings," says Tony Chapman, director of strategic programs for Rockwell Collins Global Airports business, "and it is substantial."

The companies are initially focused on facial recognition as a nonintrusive biometric identifier that does not require preregistration, particularly for travel outside the U.S. where passports are largely equipped with microchips that store traveler facial information. That data, which typically includes distance between eyes and from eyes to mouth, along with other measurements, can be captured by cameras at the airport to initially verify identity and link to back-end computer systems containing travel documents, including tickets and boarding passes. From that point on, the facial image and accompanying information can be a surrogate for physical documents. Both Rockwell Collins and SITA have back-end systems installed at airports for other services.

Besides privacy concerns about sharing of biometric data, the use of facial recognition across all airports is challenging, as there are no common

standards for what information should be captured and how a match should be computed. "Everyone is looking for something more unique than facial [features]," says Chapman. "It's good, but you have to look up at the camera." He says state-of-the-art facial recognition software has a failure rate of less than 1 in 100,000, and when identifying one passenger out of a pool of several hundred expected to board a flight, the accuracy is "very high." Other uniquely personal biometric features being researched include the pattern of veins in the hand, earlobes, gait, and combinations of biometrics such as facial recognition and voice. Chapman notes that Rockwell Collins's systems can work with any type of biometric technology.



Facial recognition systems use cameras to capture geometric facial features.

MAXIPHOTO/ISTOCK

The difference between paperless self-service in the grocery store checkout and self-service at an airport is significant: The person who bought a ticket must be positively identified and linked with travel records at numerous points along the outbound or inbound journey, with false alarms and exceptions kept to a minimum. Government agencies must also have access to the information to determine if the passenger is allowed to fly or if additional scrutiny should be applied. Once identity is validated as matching a government-issued identity, a "single travel document" can be electronically compiled to include boarding passes and other documents linked to that passenger.

Industry is taking a "crawl before you walk" approach to the single travel document, with at least one operational program (CLEAR) and a number of ongoing or completed proof-of-concept trials providing data. CLEAR is a privately run registered-traveler program, similar to the Transportation Security Administration's (TSA) PreCheck and Global Entry, which allows passengers—after paying $179 per year, passing a background check and providing biometric information—to access dedicated security lines (or customs lines for Global Entry) and minimized screening at checkpoints. CLEAR is operational at 14 U.S. airports, allowing passengers to pass through dedicated security checkpoint lanes quickly by scanning boarding passes and fingerprints as identifiers.

CLEAR last year began offering a "biometric boarding pass" for members flying on Alaska Airlines from the Mineta San Jose International Airport in California as part of a pilot program. The system matched a passenger's fingerprint to boarding records in Alaska's back-end system, removing the need for paper or electronic mobile phone boarding passes. CLEAR says the trial is complete and was successful.

The Rockwell Collins and SITA work is broader in scope, addressing the overall ground portion of a trip for travelers and not necessarily requiring preregistration or finger-printing.

In the Rockwell Collins vision of the future, the traveler uses a traditional booking process and arrives at the airport. At the checked-bag-drop kiosk, passengers scan their passport and stare into an infrared facial recognition camera to compare their features with the biometrics stored on the passport, link with travel documents in the back-end system and share the information with government authorities handling security.

The kiosk automatically programs the traveler's electronic external or internal bag tag. The passenger drops the bag off and heads to the security line, where another facial recognition camera verifies identity; hand luggage is scanned as it is now. If the passenger does not have checked bags, he or she will likely go directly to the security checkpoint for the initial check-in and biometrics match. At the gate, another facial recognition camera controls the boarding line to the jet bridge, opening a gate if it correctly matches the facial image with records.

At the destination, the biometrics registered on the outbound leg would then be used for a paperless arrival process at customs and immigration. Chapman says this last step is a long-term goal, as it will require governments to agree on what data are collected, transferred, stored and deleted, processes that are slow and deliberate. He notes that the work is "purely internal Rockwell Collins-funded research and development" that has been ongoing for 18 months.

Chapman says the idea for electronic single travel documents was hatched almost a decade earlier, after a project for some African countries that had issues with passengers leaving with a passport, then destroying it en route. They would arrive in the U.K. without travel documentation as economic immigrants. "We did a trial where on the outbound leg, we would take a picture of the traveler and their passport during the boarding process," says Chapman. "Then when you arrived in the U.K., they knew who was who." He says it was a very manual process, but that it "started our thinking on how to automate this whole process."

He says the company is "production-ready" for an outbound-only self-service system and is working with airports and airlines in Europe, Asia and the Middle East to secure a trial installation for the outbound leg only. The challenges include the cost of infrared facial-recognition cameras that are not dependent on ambient

lighting—they cost about $3,500 each, and "hundreds" are needed for a large "Tier 1" international airport—as well as privacy concerns related to how long the airports can keep the database and how to match passengers wearing facial scarves and burqas.

The SITA long-term vision is similar but takes advantage of personal smartphones or wearable devices as the facial image recording and storage medium for the biometrics and a secure "blockchain," or electronic public record, updated by the system operator—usually the government—to capture a history of recent airport check-ins, in part for security purposes.

Travelers arrive at the airport with their smartphones preprogrammed with biometric data and passport information; they then take a selfie to verify that the passport and the holder of the phone match. At the airport there will be facial-recognition cameras at certain points to ensure the passenger has not passed the phone to someone else.

The phone connects with the back-end systems, and passengers are "recognized" at various points, after they enter the doors until they board the aircraft. At the bag drop, the kiosk recognizes phones and prints tags. At the TSA checkpoint, the passenger pauses for a facial recognition camera that matches with the information on the smartphones, while the blockchain record gives authorities information that may alter how they inspect the carry-on luggage. "Today the people scanning your carry-on have no idea where you are going," says SITA's Irminger. "We apply the same process to 100% of passengers because security agents do not have any information on the passenger and their itinerary. If you are going on a trip to Iran or Turkey, they probably should pay more attention to what you are carrying as opposed to if you are going to New York or Boston."

Once past security, the phone will also be used to access the airline lounge or duty-free shops, confirming identity and opening the doors. Facial recognition cameras clear the passenger for boarding as well as for customs and immigration on the inbound leg.

While that vision is farther off, SITA continues to research the building blocks. The company recently completed a proof-of-concept trial for its Smart Path program at the Hamad Airport in Doha, Qatar. Announced in March, it will use facial scans in lieu of travel documents, similar to Rockwell Collins's approach. For the Hamad test, participating transfer passengers first enrolled at the entrance to security screening. Once the facial image was matched to the passport, the passenger's identity was then checked at an automatic boarding area gate.

CLEAR

CLEAR uses fingerprints as the biometric technology of choice for identifying passengers in its for-fee program.

Irminger says approximately 3,400 passengers participated in the trial, which was limited to certain flights. Initially, the system failed to identify approximately 25% of participants due to a number of factors, including name-matching between the passenger's passport and boarding pass, visa requirements and the quality of the data embedded in the passport. After installing software SITA developed for name-matching, the failure rate was reduced to 3%, says Irminger. Passengers who were unable to use the gate were processed manually. Name-matching problems included mismatches due to name truncation between the passport and boarding pass, passengers changing their name after a marriage and travelers who use multiple first and last names interchangeably.

New research and testing will include methods allowing use of the single travel documents for a full trip. "If you do something at one airport and one airline, how can you use the same information for a connecting flight, or at the destination, or for a future trip?" says Irminger. "Deployments and trials for biometrics today are restricted to a single airport and country. Today, when traveling between airports, passengers have to both present their passport and verify their biometric at each airport, because there is no way for storing and sharing the information securely across multiple airports and countries. The data is very sensitive. You do not want anyone to hack into it."

"Today . . . there is no way for storing and sharing the information securely across multiple airports and countries."

One potential method would be to obtain the passenger's permission to use biometrics stored in an encrypted electronic envelope, which could then be opened by security agents, to verify outbound passenger identification and also used at the connecting airport and final destination—with an associated update and check of the blockchain to verify the information has not been tampered with.

SITA hopes to launch a multiairport, multigovernment trial before year-end. "Right now we are looking for what would be the right combination between airports, airlines and countries where we could do a proof-of-concept showing the system in operation. This will be something no one has done before."

Gaming Ground

Dynamic simulation capability readies airports for the unexpected

John Croft Washington

A portable gaming simulator designed to aid European airports in creating an optimal collaborative environment is also helping officials figure out how to keep facilities functioning when things go terribly wrong.

Developed by Eurocontrol under a Single European Sky research program, the simulator includes a rack of electronics, desktop computers, a server and several large wall displays to emulate an airport operations room at host airports. The system includes a Comprehensive Airport Simulation Tool built by Germany's Airport Research Center and an Airbus-built interface to real-time airport data.

Denis Huet, an engineer at Eurocontrol's Airport Research Unit, says the simulator is designed to replicate the behavior of "almost all processes at an airport." Included are runway activity, departures and arrivals, gates, deicing pads and passenger activity in airside and groundside terminals, including boarding areas, security and border control. "You can see the interdependencies and links between all the elements," he says.

The idea is to bring all of the airport stakeholders together in one room and run predefined operational scenarios that evolve dynamically. Eurocontrol decides the scenarios with the airport beforehand, but participants—including airport operations staff, representatives from the airlines and air traffic control—do not know what is going to happen. The simulator's key elements include a dashboard that integrates data from all activities, alerting functions and chat lines.

"What we do with our simulations, which are also validations, is first do the exercise without the dashboard and warnings, then with those functions turned on, and compare," says Huet.

Although the scenarios are preplanned, the travelers, their baggage and each aircraft are "agents" in the simulation, with corresponding behavioral models that react to actions taken by the simulation participants. "We did some simulations with leisure travelers behaving differently from business fliers," says Huet. "The airports figure out what data needs to be shared to handle the reaction to different problems. The problem they are all facing is to extract what is really relevant, so as to get a high-level view of what is happening at the airport. The [hope] is to get an idea of all the processes in a simple way."

During a simulation at Paris Charles de Gaulle in May—the first test of the simulator outside of Eurocontrol's labs—one of the scenarios represented what Huet calls a "very bad day."

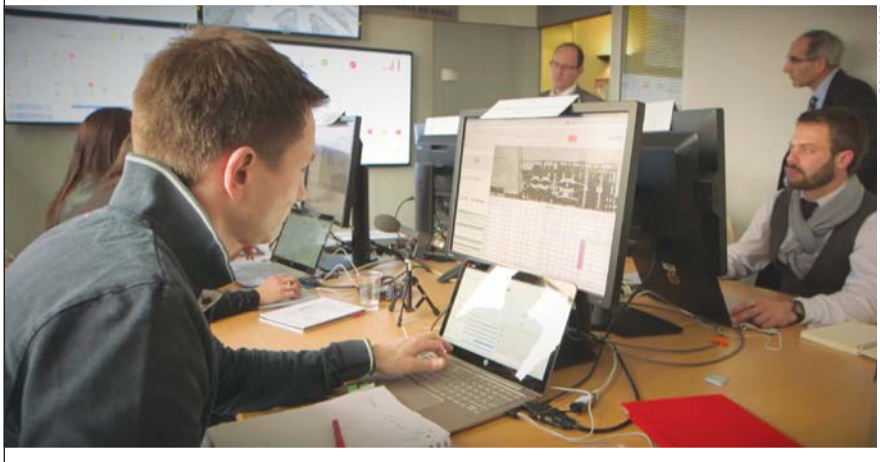
"We worked on a flight schedule and a specific set of events, including a strike of security people in Terminal 1, a fire on one satellite of Terminal 1 and smoke that affected the northern runway capacity, reducing departures and having an impact on passenger processes and throughput," says Huet. "We had to close the satellite and rearrange, in real time, the operation of the other satellites, moving people and resources." Participants included the senior operations officials in charge of crisis response at Paris and the manager of Terminal 1.

After the terrorist attacks in Brussels in March, there was a spike in interest for security simulations, a surge that may be repeated after the June 28 Istanbul attack. Huet says Eurocontrol at its Brussels laboratory last year conducted a gaming simulation with Munich Airport officials, using a bomb-scare scenario similar to what the airport experienced in January 2010, an incident that resulted in the facility's closing. In the 1-hr. simulation, airport officials closed "a big part" of the terminal. "We can plan what will happen and see what the airport operators will do," says Huet. Options include moving security people, reorganizing passenger flows and closing parts of the terminal.

Eurocontrol has built a second simulator and will be taking both on the road. In July, a system will be taken to Alicante-Elche Airport in Spain for simulations, and in September, systems will be temporarily installed at London Heathrow and Madrid Barajas. "For London, we have the model that simulates all the airside activities and all landside activities in Terminal 5," says Huet, noting that models typically take about six months to build. He says Eurocontrol is seeing interest in the gaming simulations from airports in other parts of Europe and "strong interest" from Dubai International Airport.

Future work on the simulator includes linking to real-world data streams from airport operations, giving the simulator a live, virtual and constructive capability. Included will be a connection to the airport operations database, schedules and weather. Currently, the simulator cannot run scenarios when coupled to live data.

"First, we'll do predefined scenarios, then move to a real-time environment in shadow mode before going to real-time operations," says Huet.



EUROCONTROL

A Paris Aeroport operations team works through a scenario as part of a Eurocontrol-run gaming simulation this year to help Charles de Gaulle Airport operate more smoothly during disruptions.

Saving Private Pilots

Chronic GA fatality rate drives FAA, industry action

John Croft Washington

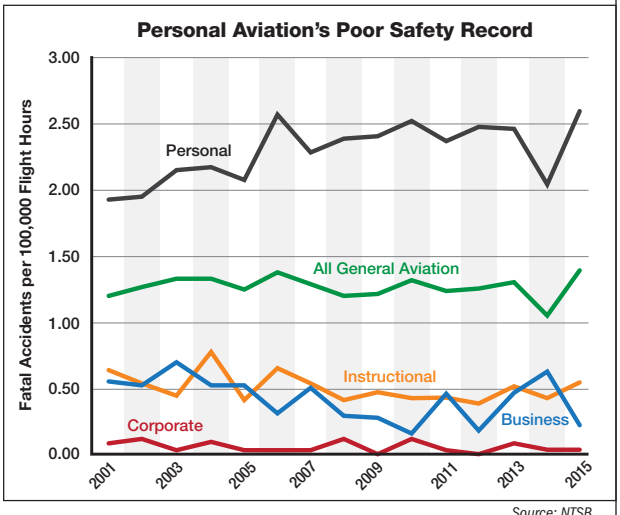
NTSB

The NTSB said the pilot of this Kitfox light sport aircraft in Florida likely entered a stall on the base-to-final turn, a familiar fatal accident scenario for general aviation.

The NTSB's cadre of 53 air safety investigators can practically plan their annual workload based on a stubbornly persistent statistic: Each year there will be about 225 fatal fixed-wing general aviation accidents.

All too often, even before arriving on a crash scene, investigators can guess the cause—loss of control (LOC), the culprit in nearly half of the fatal accidents every year for more than a decade. The problem is so persistent that the NTSB has put it on its Most Wanted list of safety improvements for two years running.

The composite "all" general aviation fatal accident rate has been slightly decreasing over time, but the trend for personal aviation has been moving in the opposite direction.



Source: NTSB

While U.S. air carriers have driven their fatal accident rates down to 0.01 or fewer per 100,000 flight hours in the past decade, the rate for fixed-wing personal aviation, covering approximately 150,000 aircraft flown largely for pleasure, is more than 200 times greater (more than two fatal accidents per 100,000 flight hours) and increasing, according to the NTSB. The broader general aviation (GA) fatality rate is fairing much better at approximately one per 100,000 flight hours, thanks to the significantly lower accident rates for business, corporate and instructional flying.

The dubious distinction for personal aviation has galvanized government and industry to unify and launch a broad slate of interventions and strategies to tackle the issues, particularly LOC. Included are efforts to improve pilot performance—in training, medical fitness and with aircraft human-machine interfaces—and safety technologies for the existing fleet and new builds.

"This is the first time I can recall seeing the Experimental Aircraft Association, Aircraft Owners and Pilots Association, National Business Aviation Association and flight instruction community all lining up to work on LOC as the No. 1 issue," says NTSB board member Earl Weener. "That's 45% or so of our fatal accidents." Weener, a pilot and aerospace engineer who worked at Boeing for more than two decades before joining the NTSB, has spearheaded several industry gatherings to address GA safety, including a "Humans and Hardware" symposium in October and an LOC safety seminar in May.

The GA community is focusing on interventions that are based on forensic data following the playbook created by the government and industry Commercial Aviation Safety Team (CAST), which deployed interventions that helped the U.S. airline industry cut its fatal accident rate by almost 80% between 1998 and 2008.

The GA CAST is managed by a government and industry group, the GA joint steering committee (JSC), that adopted the CAST process in 2011 and by 2015 had issued 33 safety enhancements to tackle the biggest problems. The process involves teams that analyze the forensic data and propose solutions, teams that implement the most promising interventions, and teams that evaluate the results of those upgrades. The steering committee's goal is to drop the overall GA fatal accident rate per 100,000 flight hours to one or fewer by 2018, a 10% reduction from 2009.

A similar CAST process adopted by the helicopter community in 2005 is showing promising results in the U.S., with fatal accident rates down to 0.57 per 100,000 flight hours in 2015, well below the FAA's target rate of about 1.0. For commercial aviation, a new CAST program is underway to halve the 2011 fatal accident rate by 2020.

Based on an FAA forensic analysis that identified LOC as a factor in 40.2% of fatal GA accidents in 2001-10, the JSC launched 29 interventions for LOC directed at two different phases of flight: approach and landing and "other phases." An additional four safety enhancements cover engine failures, the second most frequent cause of personal GA fatal accidents behind LOC.

"LOC at its core is a human performance issue," says Weener. "Although problems may arise, these aircraft remain flyable; it's the pilot's lack of familiarity with the aircraft, medical or substance impairment, distraction, insufficient training or failure to act swiftly that in the end causes the crash."

Included in the 33 safety enhancements are measures to bolster flight training (tackling over-reliance on automation and poor aeronautical decision making, and introducing safety culture

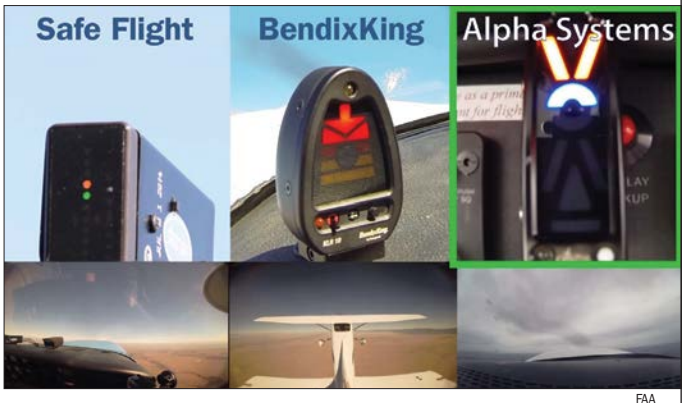
and risk-based flight reviews); efforts to make it easier and cheaper to introduce technologies to help recognize and respond to energy state issues (putting angle-of-attack, autopilot, weather and engine-monitoring technologies onto the flight deck) and initiatives to educate pilots about the effects of over-the-counter and other medications that can have dangerous effects.

When the JSC considered its first batch of LOC safety enhancements, the top-ranked intervention was for pilots to install angle-of-attack (AOA) systems, wing-mounted sensors and cockpit displays that provide visual, auditory or tactile feedback on the aircraft's AOA in all flight regimes. The devices provide pilots an optimal target AOA to fly at low airspeeds in the traffic pattern, as well as cautions when the aircraft is nearing its critical AOA, beyond which the wing will stall and the aircraft will drop. At low altitude in the traffic pattern, a stall is often not recoverable, particularly if the aircraft is in uncoordinated flight and a spin develops. While many light aircraft have on-off stall "horns" that light up or produce a tone when the wing nears the stall AOA, the devices only activate near the stall and may not provide enough warning time.

"We went through 90 accident reports in each of two [LOC] working groups. We evaluated what went wrong, as well as contributors and possible interventions," said JSC member David Oord at the October NTSB event. The potential interventions were ranked in terms of feasibility and cost, with the highest-ranking actions grouped into safety enhancements to be implemented. "AOA scored the highest because it was relatively inexpensive and could be done quickly," said Oord, the manager of regulatory affairs for AOPA.

"Relatively inexpensive" was a truism for the experimental and homebuilt aircraft sector—for which equipment does not have to be FAA-certified or installed under a supplemental type certificate (STC)—but not so much for the Part 23 light aircraft sector, which accounts for most GA aircraft. The pilot of an experimental aircraft could install an AOA system for about $1,500, but an equivalent system on a certified aircraft would cost $10,000, plus installation. The same is true of autopilot systems, which for experimental aircraft can include passive and active envelope protection, functions the JSC determined would help prevent LOC accidents. But whereas an autopilot can be installed in a homebuilt aircraft for about $2,500, the same system for a Part 23 aircraft can cost $10,000-15,000.

In response, the FAA developed a process to weigh benefits versus risk that ultimately allowed aircraft owners to install the AOA systems as "minor" rather than more expensive "major" modifications. The agency then updated its policies to make it easier and less costly to install other "non-required" safety-enhancing equipment as well, including terrain advisory systems, attitude indicators, energy-absorbing seats, monitoring systems and autopilots.



FAA

The Experimental Aircraft Association (EAA) has launched its own effort to seek out safety technologies for the experimental and homebuilt community. At the annual AirVenture gathering this year, EAA and Airbus will award the inaugural Founder's Innovation Prize of $25,000 to the best intervention designed to reduce LOC accidents in the sector by 25% in five years and 50% in 10 years. The top five finalists will compete in a "Shark Tank" format at AirVenture, with industry icons acting as judges.

While the FAA policy changes are an ad hoc means of allowing certified light aircraft to begin using safety equipment widely available to the experimental market, an overhaul of the Part 23 light-aircraft certification rules is expected to codify a paradigm shift to risk-based approvals of equipment designed to consensus standards for the next generation of light aircraft. The FAA is evaluating public input on the draft rule, published in March, but has not said when a final rule might be published.

Lessons learned from the nascent AOA experience shed some light on what problems could be caused by an onslaught of new gadgets into the cockpit. While not widely adopted, owners who have installed AOA systems are finding a wide variety of displays on the market, some of which are "opposite to stereotypes," says Dennis Beringer, senior scientist for flight crew performance research at the FAA's Civil Aerospace Medical Institute (CAMI). An opposite stereotype could be a display that shows a lower angle of attack higher up on a vertical scale, a counterintuitive design from the pilot's perspective. "Preliminary data supports that stereotypes do matter and make a difference in performance," he said at the NTSB forum in October, adding that testing at CAMI showed that pilots felt a "wing-shaped display" was the most intuitive.

The FAA recently published a video showing the similarities and differences in three AOA systems available to GA pilots.

Jim Higgins, an associate professor in the University of North Dakota's (UND) aviation department and member of the working group that recommended AOA systems, said the college last year installed AOA devices made by three different vendors in three aircraft. Based on flight data, the university found that aircraft with AOA systems on average were flown with a 0.7 deg. lower nose angle in the 90-deg. turns from the base leg to the final leg of a traffic pattern, a location where many stall-spin LOC accidents occur. Higgins, speaking at the NTSB's October forum, said the results could suggest that pilots of aircraft with AOA systems may be flying with a larger buffer from stall.

Regardless, Higgins said, instructors and students "universally panned" the AOAs. "Some of it was the design, some was the performance differences [between the different devices]," he said. The feedback led to some changes by the manufacturers but also pointed to the need for standards for information display on the systems and training information about using the devices. "What happens when airspeed contradicts AoA?" said Higgins. He added

that UND was developing a training curriculum and best practices for the AOA systems to be installed in a couple dozen aircraft at its Phoenix location.

"I'm not trying to throw the LOC working group under the bus, because I was a member of it, but the safety enhancement at the time didn't really talk a lot about the training part," said Higgins. "We just slapped this equipment on according to the regulatory requirements and naturalistically looked at how people would fly differently with it."

The FAA in June published a 20-min. video discussing the operating differences between AOA systems built by three vendors.

Not all interventions will require new devices. The Aircraft Owners and Pilots Association (AOPA) is working with UND's aviation department to test a circular landing pattern used by the military, an operational modification officials think can reduce the stall-spin problems occurring in the rectangular landing patterns taught to and used by virtually all GA pilots.

George Perry, senior vice president of the AOPA Air Safety Institute (ASI), says the circular pattern, which he used as a U.S. Navy pilot, is "easier, more stabilized and allows the pilot to more easily identify the precursors of an impending stall" than the traditional rectangular pattern. "The only pilots who do the crazy box pattern are the GA pilots," he says.

The study, which started in June, will "get hard data to show whether it is a better way to fly a pattern based on workload and standardization," says Perry. A preliminary study with 13 pilots flying a wide variety of aircraft (Cessna 140 to Cessna Citation) at AOPA's headquarters in Frederick, Maryland, showed that the pattern "works for a full spectrum of GA aircraft," says Perry.

If the results of the UND study are positive, Perry says, ASI will work with the FAA to introduce the concept to pilots in training and testing materials. "My goal is that in 3-5 years, the square pattern will [have gone] the way of the Dodo bird."

ASI is also working with the EAA, FAA and National Association of Flight Instructors on an accident-prevention and accident-awareness-based curriculum for flight instructors, potentially with financial incentives for pilots who use these instructors for their FAA-required biennial reviews.

Rules Needed

Transitioning to electric power is taking longer than expected

Thierry Dubois Lyons, France

Pipistrel plans to deliver the first Alpha Electro in August.

Visitors hoping to see electric aircraft flying at the EAA AirVenture show in Oshkosh, Wisconsin, are likely to be disappointed.

While manufacturers or would-be manufacturers of such light aircraft—including Pipistrel, Aero Electric Aircraft Corp. and Airbus Group—will be exhibiting, the lack of suitable certification rules in the U.S. and Europe seems to be impeding progress. Meanwhile, motor supplier Siemens AG sees electrifying general aviation as an indispensable step toward implementing hybrid power on commercial aircraft.

The Sun Flyer is scheduled to start ground testing after EAA AirVenture.

AEAC

Despite its dozen Taurus Electro G2 motorgliders in service—and plans to work on another electric two-seater, the Alpha Electro—Ajdovscina, Slovenia-based Pipistrel will not be bringing its electrically powered aircraft to Oshkosh, says CEO Ivo Boscarol.

"The light sport aircraft [LSA] regulation does not accept electric [engines]," he says, adding that the creators of LSA consensus standards, while ruling out turbine engines, "did not think of electric."

In Europe, Pipistrel has been struggling with regulators over the maximum takeoff weight (MTOW) of its electric aircraft. The company is offering the Alpha Electro, an electric version of an existing two-seat aircraft designed for flying schools, as a microlight that by definition must comply with an MTOW limit of 472.5 kg (1,040 lb.).

With a full load of batteries, the Alpha Electro's endurance is 1 hr. plus a 30-min. reserve. But with an empty weight of 377 kg (830 lb.), the aircraft has a weight margin under the rules for only one pilot. To carry a passenger, the pilot would have to remove some batteries, bringing the endurance down to barely 1 hr., Boscarol says.

Based on his efforts to increase the weight limit for electric aircraft, the Eu-

ropean Aviation Safety Agency (EASA) last year initiated the legal process to increase the maximum to 540 kg. The European Parliament will take up the issue in September.

Asked whether the extension would be unfair to conventional aircraft, Boscarol says "no." A source familiar with microlight operations in Europe explains that many owner-pilots routinely flout the MTOW rule. "The authorities do not have enough resources to monitor this but insurance companies, in case of an accident, do check everything," the source says.

Despite this current limitation, the airframer has received "about 20-30 orders" from several countries: Australia, Belgium, the Commonwealth of Independent States, Indonesia, New Zealand and Switzerland, among others, Boscarol says. Deliveries are set to begin in August, with a production rate of "two or three [aircraft] per month."

Pipistrel, however, has not decided on the production motor for the aircraft, according to Siemens. The German company supplied the 85-kW electric motor for Pipistrel's WattsUp, the prototype for the Alpha Electro. The Alpha Electro's data sheet indicates a 50-kW motor at 2,200-rpm engine speed.

Boscarol says that in-service maintenance of an electric motor is much less than for piston engines. "There are almost no rotating parts—just bearings," he notes. A battery life of 2,000 cycles is on par with the time between overhaul of a Rotax internal combustion engine.

Airbus Group's electric efforts are not as advanced as Pipistrel's, but the Toulouse-based company remains committed to building a light-electric-aircraft factory.

The E-Fan 1.0 demonstrator crossed the English Channel in July 2015, proving it could fly for 45 min. with one person on board. In the last few months, Airbus has been using the aircraft as a flying testbed but is undecided about bringing it to Oshkosh's static display.

The company's focus is now on the two-seat E-Fan 2.0. Unlike the Alpha Electro microlight, Airbus plans to certify the E-Fan 2.0 as a light aircraft. Program director Olivier Siri is reluctant to reveal the target performance, although the E-Fan 2.0 was introduced as a 1.5-hr. endurance aircraft. "We have to educate the market on what the performance data of an electric aircraft means," he says.

The company plans to release details, including endurance, turnaround time and availability, in September or October, including possible production rates. The E-Fan 2.0's first flight is set for 2017, but no time frame for certification or entry into service has been announced.

Much of the development work is being subcontracted to Daher's design office in Tarbes, in southwest France. Daher, the manufacturer of the TBM family of turboprop singles, supports a large fleet of piston singles and has well-established links with EASA. Siri says the two entities are developing new regulations for electric aircraft.

A production facility is to be built in Pau, near Tarbes, with Airbus planning to tap local suppliers for some systems and subassemblies.

One aircraft that will be on static display at AirVenture is the two-seat Sun Flyer, an electric aircraft developed by Denver-based Aero Electric Aircraft Corp. The aircraft, rolled out on May 11, will enter testing after the show.

Performance data from a proof-of-concept aircraft will be used "to help finalize the design for the FAA-certified production version," the company says. CEO George Bye says: "Coping with the regulatory process of the conforming tests" is the main challenge to getting the aircraft in service and setting up production. He lauds "great support" from the FAA, emphasizing that some aspects of the nascent sector are "new to everybody."

For aircraft that do not obviously fit into the conventional mold, certification authorities can establish appropriate criteria, as per FAR Part 21.17b, without waiting for the standard development process.

Siemens has a rather transverse perspective on why light electric aircraft are essential to the future of larger commercial aircraft. The company helped Airbus and Safran design the E-Fan 1.0's drive train, but Airbus's vision is to eventually prove the case for hybrid-powered regional airliners (a larger version of the E-Fan may be hybrid), and Siemens supported the approach. The two companies signed a cooperation agreement in April.

SIEMENS

In July, Siemens flew an Extra 330LE aerobatic aircraft with an electric motor as a step toward its longer-term goal of a hybrid regional airliner.

Siemens's ultimate goal is to be involved in a program that would see such a regional aircraft carrying 60-100 passengers with a range of 500-1,000 nm by 2035. The company will perform feasibility studies until 2020, in part using an iron bird with large electric motors as large as 10 megawatts.

Aiding in defining certification rules for a hybrid regional aircraft will be gaining certification of a smaller product first, with engineers going through the process with a larger aircraft in mind, in Seimens's view. Progress with light aircraft motors, such as the 260-kW Siemens motor that recently flew on an Extra 330LE aerobatic single-seater, will help.

Moreover, decision-makers for buying commercial transports usually include pilots, who may be more disposed to hybrid models if they get the chance to fly the technology on a smaller aircraft first, even a two-seater.

Despite its engagement in electric light aviation, Siemens does not expect to reap profits in the segment.

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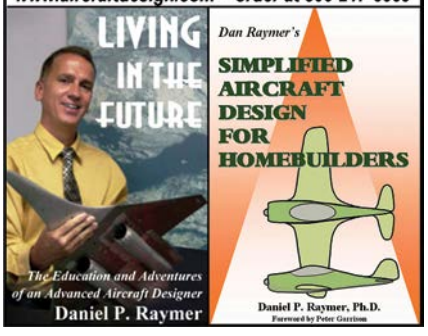

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Future Events

Sept. 14-15—MRO Network's Aero-Engines Europe. Lisbon, Portugal.

Sept. 19-21—SpeedNews 17th Annual Aviation Industry Suppliers Conference in Toulouse (AISCT-17). Toulouse.

Sept. 27-29—MRO Asia-Pacific. Singapore.

Oct. 4-5—SpeedNews 21st Annual Business & General Aviation Industry Suppliers Conference. Los Angeles.

Oct. 18-20—MRO Europe. Amsterdam.

Oct. 26—Aviation Week Program Excellence Symposium and Awards Banquet. Scottsdale, Arizona.

Oct. 27-28—2nd Annual AerospaceDefenseChain Conference. Scottsdale, Arizona.

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July 23-Dec. 3—AOPA Flight Instructor Refresher Course. Various Locations. See aopa.org/forms/event-calendar/FIRC_ONSITE

July 25-27—Propulsion and Energy 2016 Conference. Salt Palace Convention Center. Salt Lake City. See aiaa-propulsionenergy.org/?_ga=1.209423506.108956624 7.1462299197

July 25-31—EAA Airventure Oshkosh 2016. Wittman Regional Airport. Oshkosh, Wisconsin. See eaa.org/en/airventure

July 30-Aug. 7—41st Scientific Assembly of the Committee on Space Research (Cospar). Istanbul Congress Center. Istanbul. See cospar2016.tubitak.gov.tr/en/

Aug. 3-5—CAPA Australia Pacific Aviation Summit. Brisbane Convention & Exhibition Center. Brisbane, Australia. See capaevents.com/ehome/index.php?eventid=153925

Aug. 9-10—ASDE Cyber Security for National Defense Symposium. Mary M. Gates Learning Center. Alexandria, Virginia. See asdevents.com/event.asp?id=15390&desc=Cyber+Security+for+National+Defense+Symposium

Aug. 18—Satellite Finance Conference. JW Marriott. San Francisco. See satellitefinance.com/conference/89216/satellitefinance-conference-summer-2016

Aug. 20-23—Air Carriers Purchasing Conference. Atlanta Marriott Marquis Hotel. Atlanta. See acpc.com/

Aug. 27-28—International Aerospace Engineering Conference. Pan Pacific Vancouver. Vancouver. See iaec-conference.com/

Aug. 30-Sept. 1—Latin American Business Aviation Convention (Labace). Congonhas Airport. Sao Paulo. See abag.org.br/labace2016/

Sept. 3-5—2016 Cleveland National Air Show. Burke Lakefront Airport. Cleveland. See clevelandairshow.com

Sept. 5-7—Advanced Satellite Multimedia Systems Conference. Caixa Forum Palma. Palma de Mallorca, Spain. See asmsconference.org/

ADVERTISERS IN THIS ISSUE

Mixing Aircraft and Spacecraft

BLUE ORIGIN

BY LILLIAN ZARRELLI RYALS

The U.S. airspace is getting busier—and not just with more airplanes. In addition to some 70,000 aircraft traversing the National Airspace System (NAS) each day, commercial enterprises are rapidly introducing a widening variety of new space vehicles and launchers into it. And more are on the way, ranging from rockets carrying supplies to the International Space Station to vehicles for space tourism.

In 2015, 22 of the world's 86 orbital launches were commercial. And today, vertical launch vehicles with "fly-back" boosters that return to Earth autonomously, launchers that take off and land on runways, and captive-carry concepts—where an aircraft carries a space vehicle to a higher altitude for launch—are operational or in testing and production.

For the last several years, the FAA has been working on how to accommodate these new operators in the safest and most efficient manner possible. In this endeavor, it has enlisted the help of the Mitre Corp., a not-for-profit organization that operates the agency's federally funded research and development center.

> "Can we safely reduce the large blocks of airspace that must be cleared around launch and recovery sites?"

Integrating the technologies associated with commercial space operations into the NAS will require the FAA to work across all areas of its existing aviation-related activities. The agency has identified several needs that are critical to its long-term vision and goal of integrating space vehicle operations into the everyday cadence of NAS operations.

One is the ability to track space vehicles and fly-back boosters—and their jettisoned parts—as they transit to and return from space so FAA air traffic controllers and flow managers can develop and execute traffic management plans strategically and dynamically. Currently, the FAA must clear large blocks of airspace around the launch and recovery sites to ensure sufficient buffer zones, particularly in case of malfunctions.

Mitre Corp. aviation and space experts are working to identify streamlined processes and develop tools to help the FAA safely reduce the amount of segregated airspace needed, maximize NAS efficiency for existing users and accommodate the rapidly expanding number of new entrants.

Another critical need is to both protect space assets and enable and foster new commercial space endeavors. For instance, the White House's National Space Policy states that the U.S. is committed to encouraging and facilitating the growth of a globally competitive U.S. commercial space sector.

Meanwhile, legislation under consideration in Congress proposes transferring some space situational awareness tasks from the Defense Department, possibly to the FAA. While the future of the bill is unclear, it does reflect an increasing awareness of the need to address aviation and space vehicle operations in a more integrated manner. Providing high-quality space situational awareness must be a "whole of government" solution that reflects the government's responsibility to regulate, license and provide safety oversight of all NAS operations while at the same time addressing national priorities for the protection, exploration and exploitation of space assets.

Another challenging problem is finding a fiscally sensitive way to meet the needs of the Defense Department, National Reconnaissance Office, National Oceanic and Atmospheric Administration, NASA, FAA, Missile Defense Agency and myriad other space stakeholders.

Moreover, international activity in space has been increasing and is likely to continue to do so, with new space agencies being stood up or proposed around the world. The global community—including the International Civil Aviation Organization and the United Nations Office of Outer Space Affairs—will have to work closely to safely accommodate and integrate space operations into their own national airspaces while looking ahead to new ones that will eventually include point-to-point space operations.

All of these activities present challenges and will require significant work from the FAA and Defense Department to meet them, both domestically and internationally. Mitre stands with the rest of the aviation and space communities to ensure that the U.S. remains a leader in enabling and supporting spaceflight operations as the number of launches increases and their diversity broadens in the years ahead.

Ryals is the senior vice president, director and general manager of the Center for Advanced Aviation System Development, a federally funded research and development center sponsored by the FAA that addresses the capacity, efficiency, safety and security needs of aviation.

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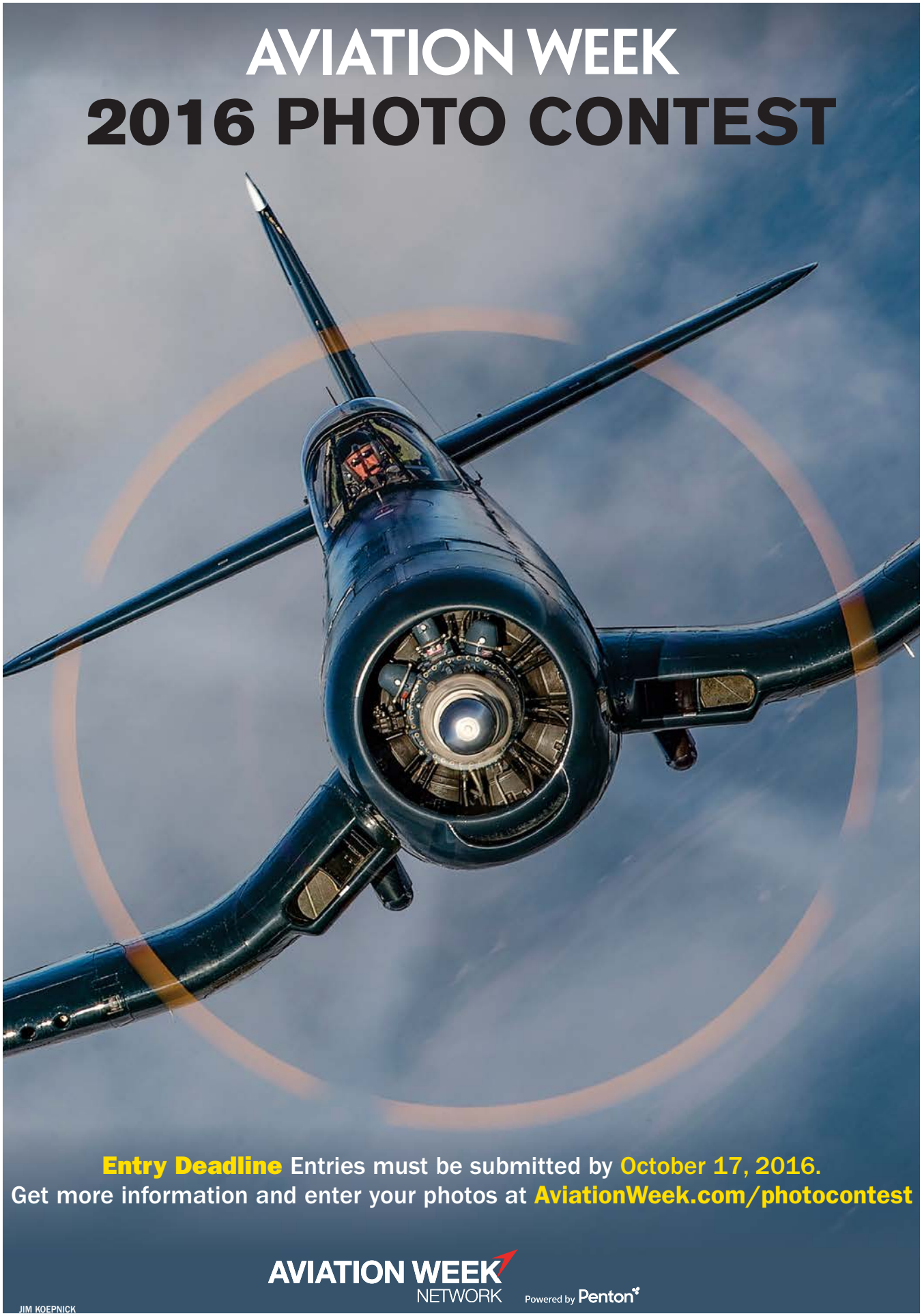
2016 PHOTO CONTEST



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JIM KOEPNICK

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