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Our 10-Year Forecast

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For individual e-mail addresses, telephone numbers and more, go to www.AviationWeek.com/editors

EDITORIAL OFFICES

1166 Ave of Americas, New York, N.Y. 10036
Phone: +1 (212) 204-4200

BUREAUS

AUCKLAND
53 Staincross St., Green Bay, Auckland 0604, New Zealand
Phone: +64 (27) 578-7544
Bureau Chief Adrian Schofield

BEIJING
D-1601, A6 Jianguo Menwai Ave., Chaoyang, Beijing 100022, China
Phone: +86 (186) 0002-4422
Bureau Chief Bradley Perrett

BRUSSELS
Rue de L'Aqueduc 134, 1050 Brussels, Belgium
Phone: +32 (2) 648-7774
Bureau Chief Cathy Buyck

CHICAGO
330 N. Wabash Ave., Suite 2300, Chicago, Ill.
Phone: +1 (312) 840-8445
Bureau Chief Lee Ann Shay

COLUMBIA, S.C.
1120 Baffin Road, Columbia, S.C. 29212
Phone: +1 (803) 727-0309
Managing Editor, AviationWeek.com Sean Meade

FRANKFURT
Am Muehlberg 39, 61348 Bad Homburg, Germany
Phone: +69 (69) 2999-2718 Fax: +49 (6172) 671-9791
Bureau Chief Jens Flottau

LONDON
50 Broadway London SW1H0RG, England
Phone: +44 (207) 152-4521
Bureau Chief Tony Osborne

LOS ANGELES
10 Whitewood Way, Irvine, Calif. 92612
Phone: +1 (949) 387-7253
Bureau Chief Guy Norris

MOSCOW
Box 127, Moscow, 119048, Russia
Phone: +7 (495) 626-5356; Fax: +7 (495) 933-0297
Contributing Editor Maxim Pyadushkin

NEW DELHI
Flat #223, Samachar Apartments,
Mayur Vihar—Phase-1 (ext.), New Delhi 110091, India
Phone: +91 (98) 1154-7145
Contributing Editor Jay Menon

PARIS
40 rue Courcelles, 75008 Paris, France
Phone: +33 (06) 72-27-05-49
Bureau Chief Amy Svitak
Contributing Editor Pierre Sparaco
pierre.sparaco@orange.fr

SAN FRANCISCO
271 Coleridge St.
San Francisco, Calif. 94110
Phone: +1 (415) 314-9056
Bureau Chief Madhu Unnikrishnan

WASHINGTON
1911 Fort Myer Drive, Suite 600
Arlington, Va. 22209
Phone: +1 (703) 997-0333
Bureau Chief James R. Asker
Administrator of Bureaus Kyla Clark

WICHITA
1500 N. Willow Lane,
Wichita, Kansas 67208
Phone +1 (316) 993-3929
Bureau Chief Molly McMillin

Art Department Scott Marshall, Colin Throm
Copy Editors Patricia Parmalee, Andy Savoie, Richard Leyshon, Diana Bell
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Content Marketing Manager Louise Rahman
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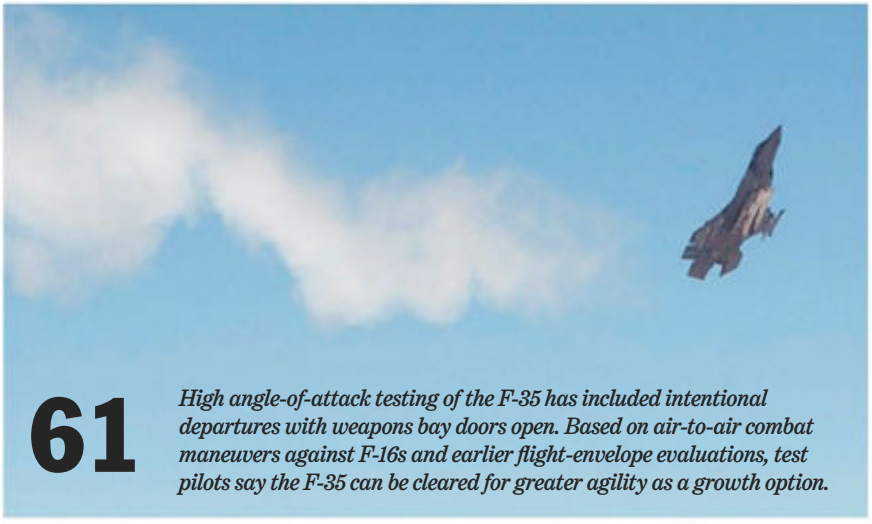


61 *High angle-of-attack testing of the F-35 has included intentional departures with weapons bay doors open. Based on air-to-air combat maneuvers against F-16s and earlier flight-envelope evaluations, test pilots say the F-35 can be cleared for greater agility as a growth option.*

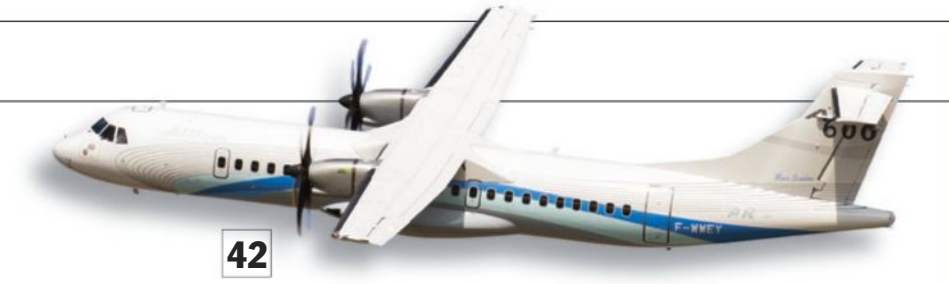
DEFENSE

SPACE

COMMERCIAL AVIATION

ON THE COVERS

This week, Aviation Week publishes two editions. On the cover far left, the landscape of U.S. national security space launches is poised to change, as SpaceX campaigns to make the Falcon 9 v1.1 (second from left) an alternative to United Launch Alliance (ULA) Atlas V (far right) and Delta IV vehicles (far left). SpaceX and ULA photos. Meanwhile, ULA plans to unveil plans for a Next-Generation Launch System (second from right) at the National Space Symposium on April 13. ULA artist's concept. As the Air Force embarks on a framework for launch competitions this year, read Air Force Secretary Deborah Lee James's thoughts on the way ahead (page 50). Elsewhere in both editions are reports on Pratt & Whitney's plans for the F-35's engine (page 26), business aviation in China (page 44) and an analysis of risks in Boeing and Airbus backlogs (page 42). On our MRO Edition cover, Delta TechOps technicians conduct a fluorescent penetrant inspection of a high-pressure compressor spool. Delta TechOps photo. That edition contains additional coverage on maintenance, repair and overhaul. Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*



42

48

BEHIND THE SCENES

Senior Pentagon Editor Amy Butler (left) conducts a wide-ranging interview on U.S. space policies with Air Force Secretary Deborah Lee James in her conference room in the Pentagon. Excerpts from the interview begin on page 50 and are followed by articles by Butler on military space, including a look at Aerojet Rocketdyne's use of 3-D printing for new rocket engine parts.

SCOTT ASH/U.S. AIR FORCE

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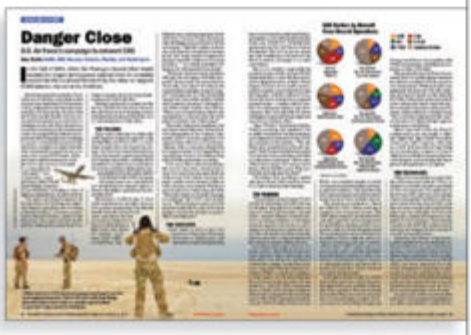
Letters should be shorter than 200 words, and you must give a genuine identification, address and daytime telephone number. We will not print anonymous letters, but names will be withheld. We reserve the right to edit letters.

OFF THE CHARTS

The Close Air Support (CAS) sorties chart accompanying "Danger Close" (*AW&ST* March 30-April 12, p. 54) appears to be a clever way of minimizing the A-10's true impact by included sorties flown by non-USAF aircraft. A more accurate presentation would show the A-10 accounting for nearly 25% of sorties flown. A chart showing how little the A-10 costs in comparison with other platforms would be even more illuminating.

A customer-focused approach is the hallmark of successful companies. In CAS, the Army is the major customer and seems to be very anxious to retain the A-10. Rather than retain a proven system that operates at relatively low cost per sortie, the U.S. Air Force wants to think "outside the box." Seems like more of the same magic thinking that got us into the F-35 mess.
USAF Col. (ret.) Michael R. Gallagher
HILLSBORO, OREGON


Danger Close

ASK THE MARINES

I did get a chuckle out of reader Leonard Capon's comment: "Sending F-35s to attack insurgents would be comparable to delivering newspapers in a Lamborghini" (*AW&ST* March 16-29, p. 6), which takes the U.S. Air Force to task for attempting to dispose of the A-10.

But I wonder what he thinks the U.S. Marine Corps F-35s will be doing as they replace the AV-8B Harrier in service? Now, don't get me wrong, I love the A-10 and what it brings to the fight, but I am curious why all the Air Force bashers are holding fire on our good friends in the Corps, who are making the F-35 their CAS platform of the future? The USMC has far fewer CAS options than the Air Force, yet the Corps is convinced the F-35 can do the job. Has anybody asked them why?
USAF Lt. Col. (ret.) Drew Metcalf
TUCSON, ARIZONA

PORTAL TO COCKPIT SECURITY

Following the tragic news of the Germanwings Airbus A320 loss, airlines are reviewing their cockpit security protocol. As a retired Boeing and Crane Aerospace engineer, I have closely followed the intense interest in the cockpit door itself, and the policy that U.S. carriers have adopted to require having two individuals present in the cockpit at all times.

The key safety factor involved is to avoid having one of the crewmembers become disabled while alone at the controls or otherwise intentionally disrupting the safety of the flight.

Since adding a lavatory to the flight deck is not practical, the solution to the cockpit security issue might easily and economically be resolved by the introduction of a secondary security "door" or sliding/folding panel immediately aft of the existing forward lavatory access door. The secondary door could be closed and monitored by a flight attendant prior to the cockpit door being opened. Secured in the "open" position while the captain or first officer briefly uses the lavatory, the temporary "extended cockpit" would eliminate concern that the cockpit is understaffed.

The secondary door design and installation would vary for specific airplane layouts, but should pose no major structural or weight-penalty challenges.
Bob Mason
REEDLEY, CALIFORNIA

SOLUTION IN THE CARDS?

The recent Germanwings disaster is a clear example of the Law of Unintended Consequences; a direct reflection of the aviation regulators' knee-jerk reaction to the events of 9/11. But there might be a relatively simple technical solution—install a card reader similar to those on modern hotel doors outside the flight-deck door.

Cards would be issued to the captain and first officer. The dispatch office, via the Aircraft Communications Addressing and Reporting System (ACARS), could change access codes for every flight to match the cards issued to the crew.

Each crewmember would be required to keep their card in his or her personal possession at all times.

It might even be possible to set up the system so the dispatch office could send an override code via ACARS to open the door. If this were done, a secure system such as the one for intercontinental ballistic missile launches would likely be required to prevent collusion between a dispatcher and a passenger bent on unlawful interference with the flight crew.

While this or other ideas are something to think about, it will probably not be possible to 100% guarantee against events such as Malaysia Airlines Flight 370 or Germanwings Flight 9525.
James Taylor, Instructional Services
CAE Oxford Aviation Academy
GOLDEN, COLORADO

ALL-ENCOMPASSING WORKER WOES

When discussions about working conditions for pilots take place, it is important to remember that many private sector jobs require round-the-clock attention and long periods away from home and family, for no added compensation. I agree that commuter airlines' copilots are grossly underpaid, but keep in mind that the high cost of earning an Air Transport rating plus an associate degree is nearly comparable to that of pursuing a STEM (science, technology, engineering, math) education.

Each of my four career employers mandated global and domestic travel on weekends and evenings. During the 1960-95 post-college era, half of all my workdays were spent traveling on company business, domestically and globally, for long stretches of time. Long workdays are the norm for private sector salaried employees as well as for commuter airline pilots.
Joseph J. Neff
INDIANAPOLIS, INDIANA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Who's Where

Jaan Albrecht

Klaus Froese

Hideki Kunugi

Linzi Barber

Ruedi Kraft

M. Woollaston

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Jaan Albrecht (see photos) has been appointed CEO of Lufthansa and Turkish Airlines joint venture *SunExpress*, effective June 1. He has been CEO of Lufthansa Group subsidiary Austrian Airlines and was CEO of the Star Alliance. **Klaus Froese** has been named chief operating officer of the extended executive board of Austrian Airlines and Tyrolean Airways. He was managing director of Lufthansa CityLine.

Terrance Paradie has become executive vice president/CFO of Cleveland-based *TransDigm Group Inc.* He held those positions at Cliffs Natural Resources Inc., also in Cleveland. As CFO, he will succeed **Greg Rufus**, who plans to retire.

Jean E. Mongillo has been appointed an associate of *Hoyle, Tanner*, Manchester, New Hampshire. She has been manager of aviation business development for the Northeast U.S.

Kwatsi Alibaruho has been named vice president-program management for the *Eaton Aerospace Group* in Fort Worth. He was director of enterprise program management for UTC Aerospace Systems and had been flight director of the NASA Mission Operations Integration Office.

Hideki Kunugi (see photo) has become senior vice president-Americas for *All Nippon Airways*. He was vice president of purchasing and succeeds **Yuji Hirako**.

Julie Albrecht has been appointed senior director of investor relations/treasurer of the *Esterline Corp.*, Bellevue, Washington. In her investor relations role, she succeeds **Brian Keogh**; as treasurer, she follows **Al Yost**, who continues as segment president for advanced materials. Albrecht was a customer service finance director for United Technologies Aerospace Systems and had been vice president-finance for customer services/assistant treasurer of the Goodrich Corp.

Linzi Barber (see photo) has become a trading manager at London Gatwick Airport-based *Air Partner's* U.K. Commercial Jet Broking Team. She was senior commercial jet broker at broker ACS and had been charter sales manager at Flybe.

USN Rear Adm. **Michael T. Franken** has been nominated for promotion to vice admiral and assignment as deputy commander for military operations of U.S. Africa Command, Stuttgart-Vaihingen, Germany. He has been interim director of Joint Personnel Accounting Command in Washington.

Ruedi Kraft (see photos) has been appointed vice president-completions business development for Switzerland-based *Jet Aviation Basel*. He was vice president-completions sales and marketing and has been succeeded by **Matthew Woollaston**.

David Zavac has been named sales manager for *TTE Filters* of Los Angeles.

USAF Brig. Gen. **Mark D. Kelly** has been nominated for promotion to major general and assignment as commander of the Ninth Air Force of Air Combat Command (ACC), Shaw AFB, South Carolina. He has been commander of the 455th Air Expeditionary Wing of ACC in Southwest Asia. Kelly will be succeeded by Brig. Gen. **David J. Julazadeh**, who has been military assistant to the deputy defense secretary at the Pentagon in Washington. Brig. Gen. **Dawn M. Dunlop** has been appointed commander of the NATO Airborne Early Warning and Control Force Command, Headquarters Supreme Allied Command Europe, Casteau, Belgium. She has been director of plans, programs and requirements at Headquarters Air Education and Training Command, Joint Base San Antonio-Randolph, Texas. Brig. Gen. **Billy D. Thompson** has been named director of services/deputy chief of staff for manpower, personnel and services at USAF Headquarters at the Pentagon. He has been chief of the Air Force Senate Liaison Office at the Pentagon.

HONORS AND ELECTIONS

David Ball, chief technology officer of NewSat Ltd., is one of four new members of the board of directors of the New York-based *World Teleport Association*. The others are: **Marzio Laurenti**, CEO of Telespazio Brasil; **Ben Vine**, vice president-media and broadcasting solutions for PCCW Global; and **Alan Young**, chief technology officer of Encompass Digital Media.

First Take

TONY OSBORNE/AW&ST

DEFENSE

Saudi Arabia has opened a second front in the war on Islamic extremism, taking on Yemen's Houthi faction with a hastily assembled but formidable coalition of Arab nations. Gulf Cooperation Council nations, with the exception of Oman, have deployed aircraft in support of Operation Decisive Storm, along with Egypt, Jordan, Morocco and Sudan. Pakistan is considering a request to join.

South Korea has chosen Korea Aerospace Industries as preferred bidder for the KF-X indigenous fighter, rejecting a late offer from Korean Air Lines with backing from Airbus. But the European company may at least partly replace Lockheed Martin as the provider of foreign technical support for the program to avoid a U.S. veto over foreign sales and integration of non-U.S. weapons (page 59).

Raytheon did not bid for the U.S. Army's Joint Air-to-Ground Missile (JAGM) program, leaving Lockheed Martin as the sole bidder. The decision is not a surprise, as JAGM has been scaled back to a new dual-mode guidance section for the AGM-114R Hellfire missile already produced by Lockheed.

Annual "unfunded requirements" wish lists sent by service chiefs to Congress for fiscal 2016 include 12 Boeing F/A-18E/Fs for the U.S. Navy, plus eight more Lockheed Martin F-35Cs. Congress added 15 electronic-attack EA-18Gs in 2015, keeping Boeing's Super Hornet line open for another year.

India is to equip two Airbus A330s with an indigenously developed airborne early warning and control system, with eventual plans for six aircraft budgeted at 5 billion rupees ($840 million). Boeing did not bid. Airbus will design and certify a 10-meter dia. (33-ft.) radome to house the electronically scanned radar.

France, Germany and Italy are to cooperate on development of a medium-altitude, long-endurance (MALE)

AIRBUS DEFENSE & SPACE

unmanned aircraft to be operational in 2025. Agreement, reached by French and German ministers in Berlin on March 31, follows a proposal for the so-called MALE 2020 submitted by Airbus, Alenia Aermacchi and Dassault Aviation last spring.

The U.S. Air Force will decide shortly how to meet an urgent request to equip, within 18 months, Air National Guard Lockheed Martin F-16s assigned to homeland defense with active, electronically scanned array radars able to counter small radar cross-section targets such as cruise missiles.

A sustained-maneuver requirement of up to 7.5g likely forced General Dynamics and Northrop Grumman to abandon existing European designs for the T-X trainer competition, but is needed to train pilots for the 9g-capable F-22 and F-35, says the U.S. Air Force. GD has withdrawn as prime contractor for the Alenia Aermacchi M-346 bid. Northrop earlier dropped the BAE Systems Hawk (page 27).

COMMERCIAL AVIATION

The next five years of deliveries by Airbus and Boeing will be placed largely as expected because they represent a healthy mix of growth and replacement aircraft, says an analysis by CRT Capital. An analysis of the companies' record backlogs suggests the manufacturers can "manage delivery positions of troubled carriers by swapping slots with their more prosperous peers" (page 42).

International courier service TNT Express has agreed to a takeover by rival FedEx valued at €4.4 billion ($4.8 billion). The deal, announced on April 7, comes just over two years after an attempt by UPS to buy Netherlands-based TNT collapsed. But the deal means that TNT's airline operations—TNT Airways—will have to be divested to comply with European airline ownership regulations.

Analysis of historical aircraft-storage data suggests 800 of the approximately 2,050 aircraft parked as of mid-March will fly again, while a sustained period of low fuel prices could see 150-200 aircraft a year stay in service instead of heading for the desert, says lessor Avolon.

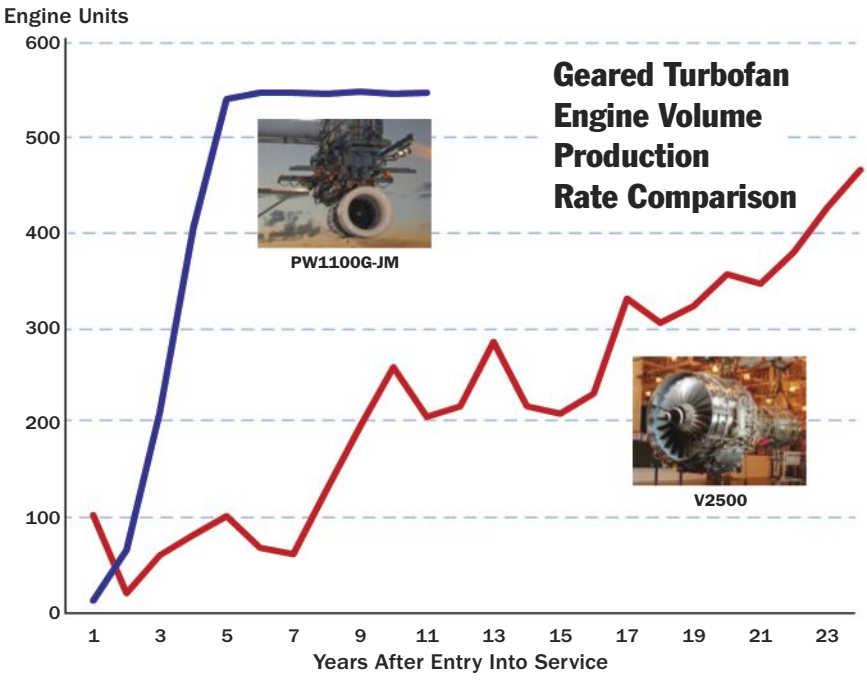
Bombardier has revamped its commercial-aircraft management as the CSeries airliner program continues to struggle for orders. Mike Arcamone has been replaced as president of Bombardier Commercial Aircraft by Fred Cromer, formerly president of lessor International Lease Finance Corp. (ILFC). Bombardier also has retained Plane View Partners, a consultancy led by former ILFC CEO Henri Courpron, to conduct an "extensive review" of Commercial Aircraft's operations.

A U.S. federal court has dismissed or ruled against three lawsuits brought by Delta Air Lines, Hawaiian Airlines and the Air Line Pilots Association that sought to limit loan guarantees made by the Export-Import Bank for foreign airlines' purchases of U.S.-built aircraft.

Pratt & Whitney is assembling the first geared turbofans for the Embraer E-Jet E2 and Irkut MS-21 airliners. The PW1900G for the E190-E2 is based on the PW1500G powering Bombardier's CSeries. The PW1400G for the MS-21 is derived directly from the Airbus A320neo's PW1100G. Both variants will begin tests later this year, with the E-Jet E2 and MS-21 to fly in 2016.

UNMANNED AIRCRAFT

Facebook has flown a prototype of the solar-powered stratospheric UAV it is developing to provide Internet infrastructure in remote areas. The Aquila subscale prototype is being flown in the U.K. The operational UAV



Pratt & Whitney is heading into a dramatic production ramp-up for the new PW1100FG-JM geared turbofan engine, which will power the Airbus A320neo. Output is expected to exceed 500 engines annually within a few years. By contrast, production of the V2500 that is on the current-generation A320 family increased at a much slower rate.

FACEBOOK

will have a wingspan greater than a Boeing 737's and be able to stay aloft at more than 60,000 ft. for months, says Facebook CEO Mark Zuckerberg.

SPACE

Arianespace orbited a second pair of operational Galileo navigation satellites for the European Commission on March 27, on a Russian Soyuz from Kourou, French Guiana. The mission follows the botched Soyuz launch in August, which injected the first two spacecraft into a lower-than-intended orbit after an upper-stage design fault. The satellites have since been repositioned.

U.S. Air Force leaders hope to "keep common sense in the discussion" as the service appeals to Congress for relief from a law that could cripple the Pentagon's access to space by limiting the use of Russian RD-180 rocket engines for Atlas V launchers (page 50).

ROTORCRAFT

Russia has begun tests of its Ka-52K naval attack helicopter despite uncertainty over delivery of French-built Mistral carriers from which the rotorcraft would operate. Visiting Russian Helicopters' Progress Arseniev plant, Deputy Defense Minister Yuri Borisov reconfirmed plans to order 32 Ka-52Ks.

A consortium of oil and gas companies has committed £60 million ($88 million) to providing helicopter search and-rescue (SAR) for offshore platforms in the North Sea. The five-year deal sees a pair of Bond Offshore Helicopters Airbus AS332L2 Super Pumas move from BP's now-decommissioned Miller platform to Aberdeen's Dyce airport, filling in a gap in the new U.K. government-run civilian SAR service.

RUSSIAN HELICOPTERS

DIED: Marat Tishchenko, chief designer of the Mil design bureau from 1970 to 1991, on March 13 after a long illness. He was 84. Tishchenko joined Mil in 1956 as an aerodynamicist, and became chief designer when founder Mikhail Mil died in 1970. He led development of the Mi-26, still the largest operational helicopter, and later the Mi-28 attack and Mi-34 civil helicopters.

34 YEARS AGO IN *AW&ST*

The space shuttle era opened with the launch of the orbiter Columbia from Kennedy Space Center, Florida, on April 12, 1981. Commanded by astronauts John W. Young and Robert L. Crippen, the shuttle completed a 36-orbit, 54.5-hr. mission, landing on April 14 at Edwards AFB, California. Columbia was on its 28th mission when it disintegrated during reentry on Feb. 1, 2003, killing a crew of seven.

Read our original coverage of Columbia's 1981 launch and other momentous events at:
AviationWeek.com/100

By Antoine Gelain

Contributing columnist Antoine Gelain is the managing director of Paragon European Partners. He is based in London.

COMMENTARY

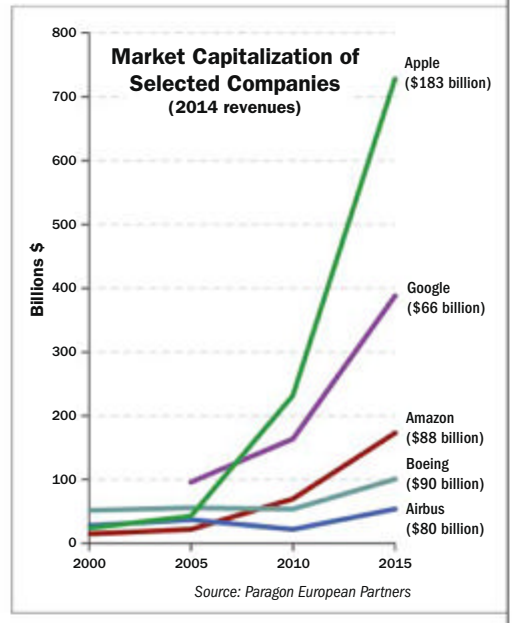
Digital Aerospace

A&D needs a revolution to stay atop its game

The era of digital aerospace is upon us. From design offices to flight decks, from clean rooms to command-and-control rooms, the digital economy is seeping through every corner of the aerospace and defense (A&D) industry, and it is just the beginning.

In this process, the industry is being turned upside down. What used to be predominantly defined by hardware is now increasingly ruled by software. Indeed, that is how the latest generation of A&D products such as radio communications systems or satellites are named: They are "software-defined" and can upgrade and reconfigure themselves.

These products are connected within networks that are themselves self-organizing and self-healing, making the whole and the parts "future-proof" against changing standards and emerging applications. Everything is controlled through software, to the point where the capabilities of a given product are more limited by its digital library than its physical characteristics.



Source: Paragon European Partners

Similarly, in commercial aviation, inflight connectivity is defining cabin interiors, while data analytics is transforming flight management and aircraft maintenance. Air traffic management is also undergoing a major software-driven revolution, with the emergence of remote and virtual control towers. A data network transfers high-definition images and all relevant airport systems to an integrated controller station that can be pretty much anywhere.

The next frontier is clearly going to be remotely piloted aircraft systems. When this happens, who will be at the forefront of the industry? Will Boeing, Airbus, Lockheed Martin and the like still be running the show? Interestingly, today there is not a single discussion about the future of aerospace that does not mention companies such as Google, Amazon or Apple. Why? Because these players are digital natives, so to speak; it is in their DNA to figure out how to create value in the digital economy, regardless of the medium. It does not matter whether it is a phone, a car, a home or—ultimately—an airplane. These are just nodes in a giant digital network. Ten or 15 years ago, if someone had predicted that Google, Apple or an Internet entrepreneur named Elon Musk would make cars, nobody would have taken them seriously. Yet it is happening.

But what exactly is happening? First, the digitalization of the economy is blurring traditional boundaries between sectors, creating opportunities for new entrants and technology spill-ins from multiple directions. Second, as the digital economy rapidly expands, the value-creation events—or economic touchpoints—are moving away from the players that are predominantly involved with hardware or platforms, which is still the case of most A&D companies.

Therefore, these companies are at risk of becoming marginalized and their products ultimately commoditized. That is why, in spite of comparable revenue and employee numbers, the market caps of Google, Amazon, Apple, etc., are several times higher than those of traditional A&D companies such as Boeing and Airbus (see graph). This value gap is a reflection of the perceived vulnerability of "old economy" players to major disruptions, be they new competitors, new technologies or new applications.

To see such vulnerability, just look at the philosophy behind the new economy's software development culture. This was captured in 2001 by a group of software developers in a statement called the "Manifesto for Agile Software Development." It essentially says improvements in software development will be achieved by "valuing individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation and responding to change over following a plan." How much further could it be from the A&D industry's traditional work practices?

To remain at the forefront of the industry, A&D players thus don't just need an evolution; they need a revolution. Instead of looking at their environment from an inside-out perspective—this is where we are, these are our options to grow and improve—they need to go through an "out-of-body" experience and look at their environment (and themselves) from an outside-in perspective, rethinking their business boundaries and purpose in the process.

By doing so, they will see a completely different picture: one where R&D is financed by venture capitalists and web entrepreneurs instead of institutional investors or industry heavyweights, where video game algorithms are more complex than a spacecraft's, where commercial technology outperforms military technology, and where collective ingenuity and individual talent trump bureaucracy and managerial processes.

Mission impossible? Probably, unless visionary leaders emerge and show the way. Until then, get used to seeing aerospace engineers being displaced by video game developers.

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By Michael Bruno

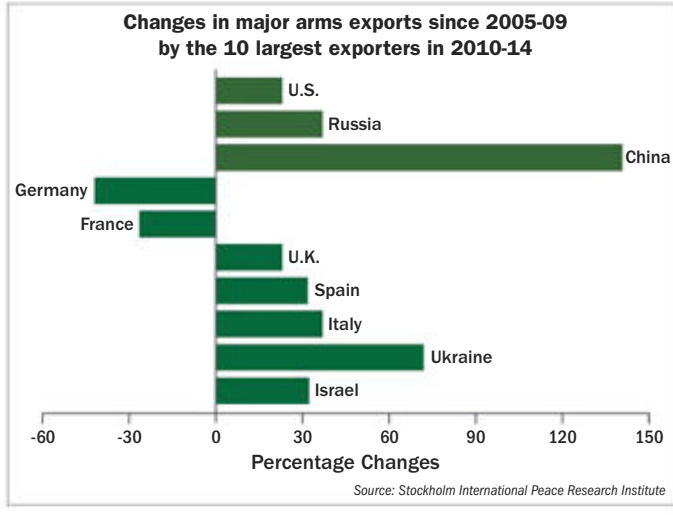
Senior Business Editor
Michael Bruno blogs at:
AviationWeek.com/ares
michael.bruno@aviationweek.com

COMMENTARY

Friendly Fire

A&D companies betting on exports have to watch out for their own governments

No wonder Rheinmetall Group has had some tough years. According to the latest, long-term data comparison across the worldwide arms trade by the Stockholm International Peace Research Institute (Sipri), Germany's arms exports decreased by 43% between the 2005-09 and 2010-14 periods.



The data echoes news reports in February that cited the Social Democrats, the junior partner in Germany's ruling coalition, trumpeting success in cutting their country's approval of new arms exports. The pullback comes as EU members like Germany and Sweden rethink arms deals in the Middle East due to human rights and other concerns in countries like Saudi Arabia, and as tensions with Russia over the Ukraine hinder other Western business deals.

For automotive and defense provider Rheinmetall, Sipri's data released March 16 also served as a backdrop for corporate financial results for 2014, unveiled days later. For last year, Rheinmetall reported operating income before interest and taxes of €160 million ($172.1 million), down from €212 million in 2013. The Dusseldorf, Germany-based company started by blaming the government's delays in defense export licensing. Automotive product growth just could not overcome that negative impact.

Analysts agree Berlin is to blame. "Significant delays in the approval of export licenses and the withdrawal of an export permit for a Russian combat-training center contract were important factors in Rheinmetall's 2014 underperformance and credit-metric deterioration," Moody's Investors Service said in December. "In seeking to exploit the growing markets of less traditional defense markets, Rheinmetall may be more exposed to countries where military and political interests may not be fully aligned with Germany's."

Boeing and United Technologies executives might sympathize, as they face the prospect that Congress may not reauthorize the U.S. Export-Import Bank (*AW&ST* June 30, 2014, p. 30) .

After the issue was temporarily shelved via a short-term bank extension so that Republicans could unite to win the midterm congressional elections, Ex-Im is back in the news. Its charter expires June 30 unless Congress reauthorizes the bank. Capitol Hill newspapers and websites these days regularly feature updates on competing lobbying campaigns between bank supporters like the U.S. Chamber of Commerce and the National Association of Manufacturers, and opponents like the Heritage Action and the Club for Growth.

In A&D, Boeing and Delta Air Lines lead industry's pro and con voices on reauthorization, and neither has been shy about speaking up, for good reason. While Boeing may not see an immediate hit to its sales prospects from a lack of reauthorization since export credit agency financing has become less significant in recent years, it could still face "long-term credit risks," according to a report last July by Standard & Poor's Ratings Services.

Indeed, S&P estimated at the time the manufacturing giant would see new financing needs totaling $7-9 billion if Boeing Capital, its financing arm, chose to fund all of the deliveries that it had expected Ex-Im to support.

"Any reauthorization will be good news to Boeing, Caterpillar, United Technologies and others that benefit from Ex-Im financing," Capital Alpha Partner analysts said in November. "Meanwhile, Delta, Valero and others may be hurt by financing for their non-U.S. competitors."

Other companies likewise are seeing the effects of their national governments pushing into or pulling away from A&D exports. While Rheinmetall reflects Germany backing away from the global arms export trade, many Russian companies are riding Russia's rise to become almost neck-and-neck with the U.S. in foreign arms deals.

For instance, in December Sipri said Russian anti-aircraft weapons-maker Almaz-Antey had become the 12th-largest arms producer and crept closer to the think tank's list of Top 10 A&D exporters. Last year also saw the introduction of a 10th Russian arms company, communication and electronics manufacturer Sozvezdie, to Sipri's Top 100.

Increasingly for many companies, market capital and national capitals are becoming aligned.

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COMMENTARY

Chairman X

Getting a speedster back in the race

By William Garvey
Business & Commercial Aviation *Editor-in-Chief*
William Garvey blogs at:
AviationWeek.com
william.garvey@aviationweek.com

When Cessna Aircraft began development of its first jet in the late 1960s, it wanted an aircraft with simple systems and docile handling that could operate from short fields. Accordingly, it was fitted with turbofan engines and a straight wing and christened Citation in honor of the fabled Triple Crown thoroughbred racehorse. The name proved ironic since the Citation's 340-kt. cruise speed made it the draft horse of the jet set.

Regardless, when deliveries began in 1972, the simple —Cessna preferred the adjective "sensible"—Citation proved to be an able competitor to turboprops, its real target, and outsold all other business jets. A stretched version, the Citation II, followed six years later, and those two models accounted for a third of all business jets delivered in 1979.

Their success notwithstanding, competitors and wags branded the aircraft as "Slowtations" and "Nearjets," and joked that they were the only jets to suffer bird strikes from the rear. In the ensuing years, the Citation line expanded considerably with models that were fully competitive in performance, but the snickering, though muted considerably, continued. And Russ Meyer, the attorney/fighter pilot who was then Cessna's chairman and CEO (photo, center), was determined to put an end to it for good. He would deliver a thoroughbred.

At the National Business Aviation Association's annual convention in 1990, Meyer announced that Cessna was developing the Citation X—the Roman numeral for 10—that was intended to be faster than any other business jet. To accomplish that, the aircraft was fitted with a wing swept 37 deg. and a pair of 6,442 lb./thrust Allison (now Rolls-Royce) AE3007s. The combination proved potent.

Upon its certification in 1996, the Citation X (photo, above) had a maximum operating speed of .92 Mach, making it the world's fastest business jet and earning Meyer and its development team the Collier Trophy that year. Upon retirement of the last Concorde in 2003, it became the fastest civilian aircraft extant.

Since then, more than 300 Citation Xs have been delivered, with some five dozen of those going to NetJets. While that endorsement by the well-known Berkshire-Hathaway fractional aircraft operator certainly helped promote the speedster, Meyer, who retired from Cessna in 2005 but continues as an active chairman emeritus, perceived trouble developing.

As with other operators, NetJets regularly replaces its aircraft, and Meyer feared that once it began to shed its Xs, particularly in a down market, values would drop, which would in turn chill any interest in new models. Two years ago, he piloted an old X that had been upgraded with a new interior and was impressed with both its up-to-date appearance as well as its performance.

He recalls, "I came back and said, 'Let's go to Honeywell and our other major partners and see what kind of refurbishing package we can put together to truly modernize the aircraft.'"

That package is called Citation X Elite. Here's what it entails: Cessna accepts delivery of a NetJets aircraft at its Wichita service center. It strips the aircraft to bare metal, removes the interior and avionics, complies with 29 service bulletins, upgrades aileron controls, and replaces components as needed. The flight deck gets a Honeywell Primus Elite avionics suite capable of supporting ADS-B Out and RNP approaches; XM graphical weather; Jeppesen electronic charts; laseref and new Goodrich crew seats. Meanwhile, the cabin gets an all-new interior as selected by the customer, including an Aircell Axxess voice, data and Internet system, a cabin management and entertainment system, and LED lighting throughout. New exterior paint is applied by King Aerospace in Oklahoma City.

"Essentially it's impossible to tell it's not a brand new aircraft in every respect," Meyer says.

Although the aircraft were in daily operation for years, Meyer maintains that's of no concern. "There is no life limit of any kind on the airplane," he says. "The airplane is just kind of getting started when it comes out of the NetJets fleet with 12,000 or 13,000 hours."

Furthermore, he notes, the aircraft were all professionally flown and maintained by Cessna.

As important as the refurbishment is the fact that Elite aircraft come with a five-year, 1,500-hr. airframe and engine parts and maintenance program with fixed hourly rates.

Cessna is marketing the reborn Citation Xs in partnership with Guardian Jet of Guilford, Connecticut. Flyaway price is $6.5 million, as compared to the list for a 2015 Citation X+ of $23 million. But Meyer says the wide discrepancy in price poses no threat to new aircraft since those buyers aren't interested in used machinery. Rather, he says, the Elite program helps strengthen pre-owned aircraft pricing and brings new people into the Citation X family. Cessna delivered two Elites last year, anticipates four more this year, six in 2016, and possibly more thereafter. And at the center of that activity is the man who helped bring the Citation X to life. "Some people like to retire, and God bless them," says Meyer, laughing. "But I want to have something to do."

By Jens Flottau

Managing Editor for Civil Aviation Jens Flottau blogs at:
AviationWeek.com/thingswithwings
Jens.flottau@aviationweek.com

COMMENTARY

Flight 9525 Lessons

The industry and regulators should take a careful approach when responding to the Germanwings A320 crash

So in the end it took a week until another task force was created: a week of intense, unprecedented media coverage of the March 24 crash of Germanwings Flight 9525 into the French Alps, which was likely deliberately caused by the first officer, a 27-year-old with a long (previously unknown) history of depressive and suicidal tendencies. The German government set up the body, as it said, to enhance aviation safety, with concrete measures in mind: one government, overseeing a few airlines, looking at unilateral initiatives. Sounds as familiar as stupid.

REUTERS/LANDOV

A quick look back to Feb. 14, 2014. That day, an Ethiopian Airlines Boeing 767-300 was en route from Addis Ababa to Rome operating as Flight 702. At one point during cruise, the captain left the cockpit to use the lavatory. The first officer did not allow him back inside and hijacked the aircraft. At this point he could have done anything with the airliner. He could have crashed the 767 into a crowded square in London, Paris or Berlin. Instead, he decided to fly wide circles over Geneva and finally land there to request political asylum. No injuries. The world forgot.

Yes, Flight 9525 (see photo) ended in tragedy and ET702 did not. They are vastly different in public perception and attention, but in both cases one of the pilots managed to take control of the aircraft because a decade earlier, secure cockpit doors were introduced that cannot be opened against the will of the person left in the cockpit.

That is the one discussion the industry and regulators should have had more than a year ago, or after the Nov. 13, 2013, crash of a Lineas Aereas de Mocambique Embraer 190 that was in all likelihood caused by the captain committing suicide: 33 people died. That the debate did not happen back then is cynical, but now that it is taking place the danger is the wrong conclusions will be drawn.

That secure cockpit doors should be relinquished, as some are seriously suggesting, is nonsense. There are still more than enough valid reasons for the cockpit to be a protected space; the threat from terrorists trying to use aircraft as weapons does not seem to have decreased over the past decade.

It took German air transport industry association BDL and air transport authority LBA three days to decide that a minimum of two people have to be in the cockpit at all times, effective immediately, with no serious discussion. That decision came even faster in Canada, New Zealand and Australia, and was widely followed by individual airlines in Europe even when their own regulatory authorities did not request it.

While there are no obvious downsides to the new occupancy rule, its advantages are also less obvious than at first sight. Would a flight attendant really stop a pilot committed to downing an aircraft? Probably not. Could a committed flight attendant with access to knives in the galley be a potential safety threat to the pilot left in the cockpit? Maybe.

The moves are clearly based on rushed judgments made under enormous public pressure. It would have been much better to defer any move, then discuss and decide when emotions no longer dictated the course of action.

If anything, the industry needs to look at whether cockpits should continue to be so secure that they cannot be entered under reasonable circumstances. Right now, the pilot remaining at the controls can relock the door from inside even when the emergency code is entered on the keypad outside, the idea being that a hijacker might force a flight attendant to reveal the code to gain access. When secure doors were introduced after the 9/11 terrorist attacks, the possibility of pilot suicide was not considered. It was taken for granted that pilots would never do something like that.

The assumption was wrong. But one still needs to put things into perspective. There have been a handful of events that can be linked to pilots intentionally crashing aircraft. But that's in hundreds of millions of flights since the late 1990s. Pilot suicides are extremely rare and before any decisions are made about measures to prevent them, a detailed analysis of potential consequences must be conducted.

A lot of the public debate in Germany has focused on whether Germanwings and its parent Lufthansa should have known more. Andreas Lubitz interrupted his pilot training in 2008 because of a severe depressive episode, but he resumed his education and passed all tests.

Would that have been enough to keep him out of a cockpit for the rest of his life? Should anybody who ever underwent psychological treatment be banned from working as a pilot? That would mean assuming depressions persist forever and discriminating against those who once were affected. And should Lufthansa have known?

Everybody has a right to have illnesses treated confidentially by doctors. Maybe what will be left is a recognition that not everything can be prevented even in the best of circumstances.

By Pierre Sparaco

Former Paris Bureau Chief Pierre Sparaco has covered aviation and aerospace since the 1960s.

COMMENTARY

The Low-Cost Chimera

Long-haul services by LCCs remain as elusive today as they were decades ago

Ryanair has once again suggested it is prepared to establish a low-cost, long-haul route system in the next few years. However, to the surprise of many industry watchers, the carrier retracted the idea three days later with little explanation. Perhaps an in-house dispute or last-minute disagreement triggered the sudden about-face. What the scenario does confirm is that, one way or another, the Irish low-cost carrier's top management is still toying with the idea, even though no viable business case exists.

DENIEL FAGET

Before he dampened expectations, CEO Michael O'Leary was talking about ordering 50 aircraft—Boeing 787s or Airbus A350s—to serve up to 15 city pairs between Europe and North America. The new venture would be, he said, the responsibility of a dedicated subsidiary; the parent airline would not be involved. Ryanair now operates 300-plus Boeing 737-800s, carries about 85 million passengers per year and largely dominates Europe's low-cost market.

Other low-cost European players in the past several months have discussed the idea of establishing long-haul routes. The most ambitious of them is Norwegian; it seeks to serve the U.S. but is still awaiting needed U.S. government approval on an application it filed in late 2013 that is strongly opposed by major U.S. carriers. The dispute is reminiscent of the ill-fated Skytrain, an initiative fronted by Freddie Laker, an innovative entrepreneur. Skytrain—launched in 1977 with a small fleet of DC-10s—offered discount fares between London and New York, and immediately encountered fierce opposition from major carriers that flew North Atlantic routes.

Reportedly, the International Air Transport Association (IATA) encouraged major carriers to squelch the upstart Skytrain. Some of IATA's most influential members were accused of an illegal coalition. When all was said and done, despite commercial success and record load factors, Laker filed for bankruptcy. Other attempts at low-cost, long-haul operations have been tried and have failed, in the U.S. and elsewhere.

Today Norwegian appears to be the most credible carrier to take up the challenge: It operates nearly 100 aircraft to 100 destinations, has ordered 262 more and has signed options for another 150.

But it, too, faces many hurdles. The ambitious 15-city-pair growth plan assumes the carrier can obtain the needed slots at New York John F. Kennedy International or Newark Liberty International in New Jersey. It would also have to contend with strict curfew constraints. Moreover, to operate long-haul aircraft more than the usual 12-14 flight hours per day needed to maintain lower direct operation costs, passengers would have to board at off-peak times. Whether enough travelers would agree to depart at 4 a.m. to save money is not yet known.

These and other such difficulties could explain Ryanair's cautious approach, and Norwegian has not spelled out its business plan.

Successful low-cost carriers (LCC) do not operate strictly short-haul routes, although some European LCCs operate long-haul flights within their regions.

A few weeks ago, Ryanair executives said they may order up to 30 widebodies for their envisioned LCC long-haul subsidiary. The Irish carrier is apparently expecting Airbus and Boeing to ultimately produce more aircraft than needed. This means white tails could be available at discount prices, analysts say. But no such overproduction is anticipated anytime soon.

O'Leary has always been provocative. Although he appears to have abandoned his long-haul LCC plan for the moment, experience has shown that it will be presented again soon, one way or another. Eventually discount flights will most probably become available on the North Atlantic—the airline industry's most prestigious route. But for now, no one has made a practicable business case.

SIKORSKY/BOEING CONCEPT

By Graham Warwick

Managing Editor-Technology
Graham Warwick blogs at:
AviationWeek.com
warwick@aviationweek.com

COMMENTARY

Future Delayed?

Foundations of future military systems at risk from near-term budget cutting

Watch congressional hearings into the Pentagon's fiscal 2016 budget, and it would seem the sky is falling on the U.S.'s ability to defend itself as the Defense Department tries to stave off spending caps that would force cuts across its programs.

The return of congressional budget caps would limit the Pentagon's spending to $499 billion and require just over $35 billion—about 6.5%—to be cut from the president's defense budget request for 2016. So in absolute and relative terms the sky is far from falling on national security, though in some areas it does look shaky.

While attention has been grabbed by service attempts to preserve funds for readiness and modernization in the face of budget reductions, by sacrificing whole fleets of aircraft—Air Force close-air-support A-10s and Army OH-58D armed scouts among them—the real damage may not be felt for decades, and be self-inflicted through efforts to protect existing programs.

Attempts to balance the national budget by trimming public spending come as the U.S. military raises its head above the parapet of two wars and begins to think about the future, and how to sharpen its eroding edge over potential adversaries. The real threat of sequestration is that the Pentagon will let the cuts fall on embryonic programs that could deliver that military advantage, but not for a decade or two.

Equally important, it is those same science and technology (S&T) programs that will sustain industry's ability to develop and produce new weapon systems in the 2020s and '30s. Across the services there are technology demonstrations planned or underway to lay the foundations for future systems. Cuts to those demos or delays to follow-on programs put industry's design and integration capabilities at risk.

Whether it is next-generation fighters and hypersonic strike weapons for the Air Force, high-speed rotorcraft and high-energy lasers for the Army, or electromagnetic railguns and autonomous cargo helicopters for the Navy, the inconvenient truth is that a return to budget caps under sequestration would deal disproportionately heavy blows to S&T programs industry needs now so it can deliver later.

Arguably the most important of those, given the Pentagon's experience with immature technology and the Lockheed Martin F-35 Joint Strike Fighter, is the Aerospace Innovation Initiative (AII) to get a head start on integrating and demonstrating airframes and engines for the next generation of "air-dominance" fighters to enter service beyond 2030.

Planned to begin in 2016, the initiative has two elements: AII-X to fly two X-plane fighter prototypes, one for the Air Force and one for the Navy; and the Adaptive Engine Transition Program (AETP) to ground-test two flight-size variable-cycle fighter engines offering 25% lower specific fuel consumption.

"Both AII-X and AETP would end under sequestration," Alan Shaffer, principal deputy assistant defense secretary for research and engineering, told a congressional hearing in March. "This would leave the Defense Department with no significant long-term research into the next generation of air capability."

After the controversial cancellation of an alternative engine for the F-35, funding two powerplants under AETP, Shaffer said, "will help sustain a healthy industrial base . . . to meet development and production needs for legacy and future platforms." Cancellation of the AII would lead to layoffs, "and once we lose aerospace engineers in the aircraft and turbine engine industries, they do not come back."

The Army is in a similar situation. High-speed rotorcraft demonstrators will be flown in 2017 by Bell and Sikorsky/Boeing (shown). But if the follow-on Future Vertical Lift Medium program to replace the UH-60 Black Hawk and AH-64 Apache beginning in the mid-2030s is delayed, the Army has warned, industry will lose design capability.

At the March hearing, Shaffer listed other key demos at risk of cuts or delays to follow-on development and production programs. These include the Air Force's High-Speed Strike Weapon, to fly both Mach 6 air-breathing-scramjet hypersonic and Mach 9+ tactical boost-glide missiles by 2019.

For the Navy, it includes the at-sea trials in 2019 of an automated electromagnetic railgun capable of firing guided hypervelocity projectiles 110-nm at 10 rounds/min., and the demo in 2016 of a 100-150-kw solid-state laser self-defense weapon capable of long-term deployment on a destroyer.

Even before any spending caps, the Pentagon's 2016 request for S&T is down 8% from 2011 and down 20% from 2009 for R&D. "The R&D budget is variable, but the cost of R&D is not. If the budget goes down, delivery will be impacted," Shaffer warned. And the cost of not investing in research and technology now is certain to be high when it is finally counted a decade or two from now.

By Bill Sweetman

Read Sweetman's posts on our blog **Ares**, *updated daily:*
AviationWeek.com/ares
bill.sweetman@aviationweek.com

COMMENTARY

Light Speed

Laser weapons could be closer than you think

May 1977 saw the premiere of an epic tale in which an evil empire deployed powerful directed-energy weapons in its quest for total domination. *Star Wars* was first shown in the same month, but *AW&ST's* serial scoops on the Soviet Union's supposed development of laser-based missile defenses were a hit in their own right.

BILL SWEETMAN/AW&ST

Inspired by ultra-hawkish Maj. Gen. George Keegan, just retired as chief of U.S. Air Force intelligence, the scoops suggested the Soviets were preparing to end the Cold War on their own terms. Within a few years, the Star Wars title had been co-opted for the Pentagon's own Strategic Defense Initiative (SDI).

Talking about megawatt-class space-based lasers (SBLs) just 17 years after the first laboratory-bench laser was like expecting the Wright brothers to build a 747. SDI quickly found that only Darth Vader could make them work. Russia's SBL program crashed along with the 80-ton Polyus spacecraft in May 1987. SDI's impractical Airborne Laser lumbered on until 2011. The only thing of consequence that any of them destroyed was confidence in laser weapons.

Today, expectations and technology have converged, and practical high-energy laser (HEL) weapons may be close to combat-ready.

New HEL weapons are smaller than the 1980s monsters, with a goal of 100-150 kw, and powered by electricity rather than rocket-like chemical systems. Modest power permits more precise optics and—in some cases—the use of commercial off-the-shelf fiber-laser sources, improving beam quality (that is, focus) and reducing cost.

Star Wars lasers were intended to hit things that missiles could not touch. The new generation exploits different characteristics: a magazine as deep and easily replenished as the fuel tank, and a low cost per shot (about $1, says Rheinmetall). The idea is to deal with targets that missiles cannot engage affordably.

A mini-UAV is a threat because it can target ground forces for artillery. It is cheaper than any surface-to-air missile, but a laser can blind it, destroy its payload or shoot it down. Rocket and mortar defense is another application. Rafael's Iron Beam laser is a logical follow-on to Iron Dome, which is practical and affordable only because it ignores rockets that will fall on open ground; that will no longer work when weapons are guided.

Close behind the systems already shown by Rheinmetall, Rafael and MBDA—certainly not a technological leap away—is the new Gen 3 HEL being developed by General Atomics Aeronautical Systems to fit on an Avenger unmanned air vehicle (*AW&ST* Feb. 16-March 1, p. 30). If what we hear is correct, it combines an output as high as 300 kw with high beam quality; it can fire 10 times between 3-min. recharges; and a version might fit in the 3,400-lb. pod that Boeing designed for the Advanced Super Hornet (see photo). A bomber or a special-operations C-130 could carry it easily.

This is a tipping point, because what you can do with 300 kw also depends on what you are trying to protect. If the goal is to knock down a supersonic antiship cruise missile (ASCM), there are two problems: water in the atmosphere (which attenuates laser energy) and the fact that a damaged ASCM can still hit the target. But if the target is an evasively maneuvering aircraft, it will often be in clear, dry air; and it is enough to destroy the missile's seeker, put a hole in the radome, even at well-sub-kilometer range or weaken the motor tube to cause a miss, even at well-sub-kilometer range.

Shooting a small, fast target is a laser's forte, because what makes it new as a weapon is its instantaneous impact. The century-old basic air warfare problem—figuring out where the target is going to be when the bullet or missile gets there—is over.

Two laser-armed fighters in a formation could act as escorts, with 20 quick shots to defeat a pop-up threat. A bomber could penetrate the outer zone of a hostile fleet's defenses. Countermeasures are expensive: Mostly they are meant to harden a missile, invariably adding weight.

Conversely, improving laser power and beam quality are engineering challenges, not alter-the-laws-of-physics problems. Something like a 500-kw, 2,000-lb. weapon—just over twice the weight of an internal M61 gun—would mean another tipping point for air warfare. Provided that adaptive optics can be developed to fire the laser through friction-heated air, a moderately agile laser-armed supercruiser would be a tough target, stealthy or not. A laser fighter would not need extreme agility, either to put weapons on target or to evade enemy fire.

But the near- to mid-term developments will have an impact: consider the reaction if, between now and 2020, a Chinese H-6 bomber variant emerges with a functioning, fractional-megawatt SAM zapper. It's a lot more likely than antimissile SBLs were in 1977—and could well cause panic on a similar level.

In ongoing military operations around the globe, the Super Hornet is the fighter forces depend upon in combat. Fully networked with integrated sensors and weapons, it delivers a full range of missions from close air support to air combat and interdiction. The Super Hornet also sets a new standard of availability, maintainability and cost per flight hour—providing the U.S. Navy with combat-proven, dominant aircraft today and for generations to come.

F/A-18E/F SUPER HORNET

RAYTHEON NORTHROP GRUMMAN GENERAL ELECTRIC BOEING

By Frank Morring, Jr.

Senior Editor Frank Morring, Jr., blogs at:
AviationWeek.com/onspace
morring@aviationweek.com

COMMENTARY

Affordable Mars

Apollo 8 moment at the Red Planet

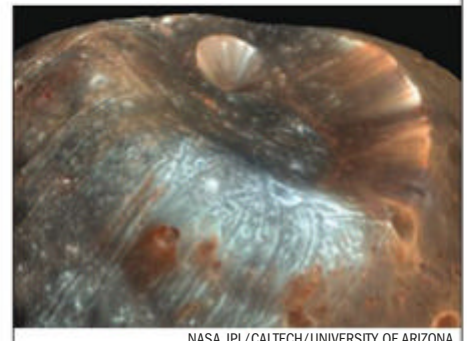
A concept study at the Jet Propulsion Laboratory concludes that it actually is possible to get humans to Mars in the 2030s. That is NASA's official goal, but the agency's plan for doing it probably will not work without an unlikely budget boost.

"If you want to be at Mars in 2033, you either have to have a budget that's two or three times NASA's current human spaceflight budget, even with inflation," says former NASA "Mars Czar" Scott Hubbard. "If you say you have to stick with the budget as it currently exists, it causes humans at Mars in, maybe, 2050."

Hubbard co-chaired a workshop at the Space Policy Institute at George Washington University that examined the "minimum-path approach" developed at JPL. With the same methodology used on NASA's "Evolvable Mars" strategy, which produced the results Hubbard cited, The Aerospace Corp. estimates the JPL concept could be accomplished with the funding NASA spends on human spaceflight today.

The idea calls for finishing the heavy-lift Space Launch System and Orion crew vehicle as planned, and shifting the budget NASA uses for the International Space Station for Mars-mission developments after 2024, the current ISS shutoff date. To make it all work, organizers of the workshop sponsored by The Planetary Society will say in a final report due out this summer, NASA must shift its goal from a Mars landing "in the 2030s," to a 30-month human mission to Mars orbit in 2033. During the year spent at the planet, the crew could explore Phobos (photo) or Demos in person, and teleoperate rovers on the planet's surface with a much shorter communications lag than from Earth.

That would set up a human landing on Mars by 2039 for a "short stay," and pave the way for the long-term "pioneering" that drives NASA's current Mars plan. It would also be a reprise of the 1968 Apollo 8 mission that heralded the lunar landings, says John Logsdon, a space historian who founded the George Washington University Space Policy Institute.



NASA JPL/CALTECH/UNIVERSITY OF ARIZONA

Phobos as imaged by the Mars Reconnaissance Orbiter. Astronauts could use it as a way-station to the Martian surface, with a scientific payoff.

"Having humans report back from Mars orbit of what they're seeing I think would have a world-changing impact on perception of where we are in the Solar System and the larger universe," said Logsdon, the workshop co-chair, noting the famous "Earthrise" photo the Apollo 8 crew took. "Apollo taught us there is a public impact to doing this, but also it broke up the Apollo profile into two parts."

Like Apollo at the Moon, the minimum path would send humans to Mars before completion of a lander to touch down there. And it would use the Moon's gravity to test the storable-propellant Mars descent and ascent system with a human landing. That flight-test mission would come in 2035 under the notional plan studied at the workshop.

The landing on Mars four years later would add supersonic retropropulsion to slow large payloads before the final touchdown, a technique NASA already is studying with infrared photography of SpaceX Falcon 9 first stages as they attempt soft vertical touchdowns at sea (*AW&ST* Oct. 20, 2014).

Between now and the Mars landing, the JPL approach would fly the planned SLS/Orion Exploration Missions 1 and 2 in 2018 and 2021, with a crew flying around the Moon on the latter. There would be a solar-electric propulsion (SEP) test in 2020; another piloted Orion flight in 2023; a robotic entry, descent and landing test in 2026; two simulated Mars missions with crews in cislunar space in 2025 and 2027, and the mission to Mars orbit in 2033.

To hold down costs, "don't do any big developments unless you absolutely have to," Hubbard says. The main developments needed for the JPL approach would be SEP with a rating on the order of 100 kw to pre-position as much as 40 metric tons of supplies at Mars, and a long-duration crew habitat. NASA is already evaluating proposals for a 50-kw SEP system for its planned Asteroid Redirect Mission, and has just entered public-private partnerships with a dozen companies to spur development of habitats and more-advanced SEP, as well as secondary-payload cubesats that can serve as tiny scouts before astronauts reach cislunar space in the Orion missions.

NASA has requested almost $6 billion in fiscal 2016 for exploration-systems development and the ISS. With a Mars campaign broken into chunks that can be bought for something like that amount, Logsdon says, potential commercial and international partners can better justify investing in some of the necessary hardware to help spread the cost, as was done on the ISS.

"You've got a framework in place where you can go out, invite international participation, saying 'here are all the things that need to be done,'" says Logsdon, who just published a book on the decision to build the space shuttle (*AW&ST* April 1). "Where would you like to participate; what contribution would you like to make? Would you be interested in being in the critical path? It gives the president, the White House, the ability to really reach out to potential partners, and it tells the private sector where the opportunities are."

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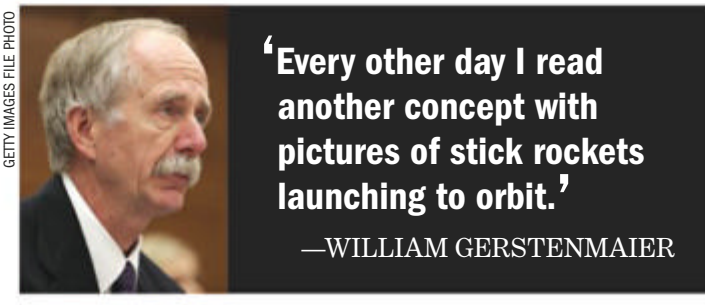
COMMENTARY

When To Go Slow

NASA official seeks more thoughtful approach to Mars travel

William Gerstenmaier, the associate NASA administrator for human exploration and operations, is getting a little touchy about quick-fix approaches for going to Mars. "Every other day I read another concept with pictures of stick rockets launching to orbit and how they're going to go to Mars in X amount of time," he tells the NASA Advisory Council. The council was being briefed on NASA's Evolvable Mars Campaign, which defers some key exploration-architecture decisions to avoid getting locked into technology that could become obsolete before it is needed. "We're kind of stepping back and saying, 'Let's get all the big-picture assumptions nailed before we start homing in on a solution,'" he says. That is in contrast to the days in which NASA "got sucked into the solution," without enough deliberation. Gerstenmaier suggests the Jet Propulsion Laboratory is following the old approach with its new concept for an expedition to Mars orbit in 2033 without a dramatic budget boost. "I see that in the humans-to-Mars thing that was just briefed here in Washington" at a workshop organized by The Planetary Society.



GETTY IMAGES FILE PHOTO

'Every other day I read another concept with pictures of stick rockets launching to orbit.'

—WILLIAM GERSTENMAIER

DRIVING COMPETITION

When it comes to the cost of the engine for the world's most expensive fighter, contractor Pratt & Whitney is still not providing a dollar figure. According to Bennett Croswell, the president of Pratt's military engines group, the cost of the Lockheed Martin F-35 Joint Strike Fighter engine is down 55% since 2009. Though that seems like a triumph of fiscal prudence, it does little to reveal the engine's actual price. Company officials say the secrecy is justified, despite the fact that the Pentagon stopped funding the competition—General Electric's F136 engine program—in 2011. "We still believe that we're in a highly competitive environment, and we treat it as such," says Mark Buongiorno, who leads Pratt's F135 program.

Pratt officials point to Pentagon acquisition chief Frank Kendall, whose Better Buying Power initiative stokes the threat of indirect competition to improve an incumbent contractor's performance or obtain "early deployment of the next-generation system." Pentagon documents refer to the Advanced Engine Technology Demonstration as an example. And that could explain the fear that GE could use the AETD as a way back into the F-35 engine hunt. But it could also help Pratt, as the AETD program may provide an avenue for the incumbent engine-maker to draw its advanced technologies into the F135 (see page 26).

POINT, BOEING

A federal court has ruled against the plaintiffs in three cases that sought to limit loan guarantees made by the Export-Import Bank of the United States for foreign airlines' purchases of U.S.-manufactured aircraft. On March 31 a U.S. District Court for the District of Columbia dismissed one of the cases, and ruled against the plaintiffs—Delta Air Lines, Hawaiian Airlines and the Air Line Pilots Association (ALPA)—in two others. The plaintiffs argued that the bank has violated the law through the way it assesses the economic impacts of its financing, the court said in its opinions, which uphold the bank's actions.

The litigation is the latest chapter in this long-running saga. A lawsuit in 2011 claimed the Ex-Im Bank failed in its statutory obligations by providing loan guarantees to financially struggling Air India for the purchase of Boeing aircraft. The court ruled in favor of Ex-Im Bank at that time. Along with action in the courts, U.S. airlines and pilots have tried to rewrite the rules for the bank in Congress. Free-market advocates and anti-corporate welfare types are objecting to the very existence of the bank. So far, that has led to ongoing lobbying wars over renewing the bank's operating authority, which currently expires in June.

ANOTHER RUN

Sen. John McCain (R-Ariz.), who spent the last year making a series of highly visible trips home—including one last summer to the Boeing plant in Mesa, where AH-64 Apaches and A160T Hummingbird UAVs are made—is seeking a sixth, six-year term. The news is not that surprising. The 78-year-old is still running at a scorching pace. And at the start of this Congress, he finally hit his stride as the leader of the Armed Services Committee. Should he win, he will be in a position to maintain that role. In announcing his decision to run in an April 6 speech to the Arizona Chamber of Commerce in Phoenix, McCain drew contrasts between his foreign policy opinions and the choices made by President Barack Obama. He said, "No success in my life has ever come without a good fight, and there is so much worth fighting for today. I'm eager to get started and ready for whatever comes."

Power Plan

Multipronged plan links F135 upgrade and sixth-generation engine product strategies

Advanced blade-cooling technology evaluated on F135 Stovl test engine XTE68/LF1 could be bundled with fuel-burn reduction improvements as an initial F135 block upgrade.

Guy Norris **Hartford, Connecticut**

Pratt & Whitney has revealed details of a mid-to-long-term development road map designed to protect both its position as sole engine provider on the Lockheed Martin F-35 Joint Strike Fighter (JSF) as well as its prospects for powering sixth-generation combat aircraft.

The ambitious plan builds on upgrades already under development for the F135 engine that powers the F-35, as well as a raft of advanced technologies currently being evaluated or studied for the next generation of adaptive, or variable-cycle engines. The strategic effort is also focused on sustaining Pratt as a major fighter-engine developer beyond the F135, the system development and demonstration (SDD) phase for which ends in 2016.

While Pratt makes it clear that there is currently no firm requirement for an upgraded F135, the company is working with the U.S. Navy on a fuel-burn improvement program for the engine, which combined with other turbine cooling technologies recently tested on the XTE68/LF1 demonstrator engine could be packaged as the first block of a two-step enhancement. "The Navy is working with us to develop technology for an engine test next year that would demonstrate a 5% fuel-burn reduction in the F-35," says Pratt & Whitney's Advanced Programs and Technology Director Jimmy Kenyon. This would be grouped potentially with blade-cooling technology demonstrated in late 2013 on XTE68/LF1, which Kenyon describes as "a fantastically successful test. It was the highest-ever turbine temperature in a production-based engine."

The block one improvement will offer between a 7% and 10% improvement in thrust, as well as between 5% and 7% better mission fuel burn, and could be available around 2018. "So far, no one has decided they need the capability but we are making sure we are providing the options," says Pratt & Whitney Military Engines President Bennett Croswell.

Although higher thrust and better fuel burn have obvious payload, range and mission advantages, Pratt expects the main benefit to come from trading the performance for lower operating temperatures and longer time on wing. "We are planning a life-extension for the F135, like we did on the [F100] -229 with an engine enhancement package where you had a 50% improvement in life. So we have set a goal to reduce sustainment costs for the F135 by a factor of 30%. A big piece of that will be increasing the life, which means reducing the number of depot overhauls you do over the life of the engine," says Croswell. "The real focus for the Joint Program Office and Navy is on reducing life-cycle cost," adds Kenyon.

For a longer-term block two upgrade path, Pratt is studying the possibility of configuring the F135 with elements of a technology suite in development for the U.S. Air Force Research Laboratory's (AFRL) Adaptive Engine Transition Program (AETP). Tipped for possible start-up funding later this year, AETP is primarily designed to prepare the ground for an adaptive, 45,000-lb.-thrust-class combat engine for sixth-generation fighter aircraft. However, the stated provisions for the program

PRATT & WHITNEY

also make it a possible future reengining candidate for the F-35, the prospect of which is also driving advanced engine development work at General Electric.

Both Pratt and GE are currently engaged in AFRL's Adaptive Engine Technology Development (AETD) program, a progenitor to AETP aimed at testing technology for a new generation of "three-stream" engines that can be reconfigured in flight. The adaptive concept is based on the principle of adding a third airflow stream outside of both the standard bypass duct and core. The extra airflow can be adapted to provide either additional mass flow for increased propulsive efficiency and lower fuel burn in higher bypass mode for cruise or, alternatively, for high-speed flight it can provide extra cooling capacity for the hot section of the engine, as well as for the fuel that provides a heat sink for aircraft systems.

AETD is set to end with demonstrations in 2016, by which time the follow-on program is scheduled to be underway. The four-year effort will mature adaptive engine technologies and reduce risk in readiness for a competitive engineering and manufacturing development (EMD) program. Pratt will conduct a preliminary design review of its AETD engine this month and has begun assembly of parts for a new high pressure-ratio core that will be tested in 2016. The manufacturer, which also has been rig-testing a three-stream adaptive fan, will attach the fan to an F135 for full engine tests at the company's West Palm Beach, Florida, facility next year. The engine will also be fitted with a three-stream-compatible augmentor and exhaust system.

"We are looking at how we can take technology from that engine and use it within an F135-based architecture. We could potentially get a lot of that capability improvement for a lot less cost because we are already starting with a known engine and looking at an upgrade," says Kenyon. "So we are working on different trades about how much the technology would bring in, how much that would cost and what kind of capability it would provide us as we go forward. The great thing about AETP is you are going to build and test and really wring out this technology, so by the time we get to the end of it that technology will be pretty mature." As a result, Kenyon adds that "getting it into an F-35 would really not be as difficult or expensive as it would be to now take it forward to a brand-new engine."

Block two would therefore take elements of the advanced engine—in particular a new compressor and turbine— and feed it into the F135 for as much as a 15% thrust increase and a 20% reduction in fuel burn. "The compressor has more stages. It fits and is compatible with the current engine," says Croswell, who adds the upgrade could be available in the 2022 timeframe if development of this, and the associated block one improvement, is approved soon. Although there is "still flow capacity in the inlet that we are not using," Croswell acknowledges that the tightly packed F-35 fuselage does not allow for much leeway when it comes to providing space for a third stream. "Lockheed would like us not to tear up the airplane a lot, so I don't know if we can integrate a third stream, but we will do those trades. We have defined what we could offer, and it is not part of the block upgrade plan as yet."

Pratt is also working with the Navy on the Variable Cycle Advanced Technology (VCAT) program, which is designed to identify and mature adaptive-cycle turbine propulsion technology for future carrier-based tactical and intelligence, surveillance and reconnaissance systems. The VCAT program, which leverages the AFRL variable-cycle work, is a partnership effort between the Office of Naval Research and ONR and the Navy's Energy Task Force, and is exploring additional unspecified methods of using the turbine stages to adapt the cycle. VCAT technology "is not part of the block two strategy right now, but it could be," says Croswell.

— With Joseph C. Anselmo and Jen DiMascio

New Training Track

USAF confident unusual industry interaction will produce a better, cheaper T-38 replacement

Amy Butler Washington

With four contenders still in the running to build the U.S. Air Force's T-38 follow-on advanced pilot jet trainer, the service is confident that the remaining competition will drive costs down to an affordable level, despite high design expectations. Alenia Aermacchi is hoping to find a new partner—likely Raytheon—after being dumped by former prime contractor General Dynamics in pitching a version of the M-346. GD announced its pullout March 26.

This leaves four other candidates, including new designs from Boeing/Saab and Northrop Grumman/BAE, as well as a modified Textron AirLand Scorpion and the Lockheed Martin/Korea Aerospace Industries T-50, though it is unclear how much modification the latter aircraft will need. Industry sources suggest Lockheed is not interested in a new-build design.

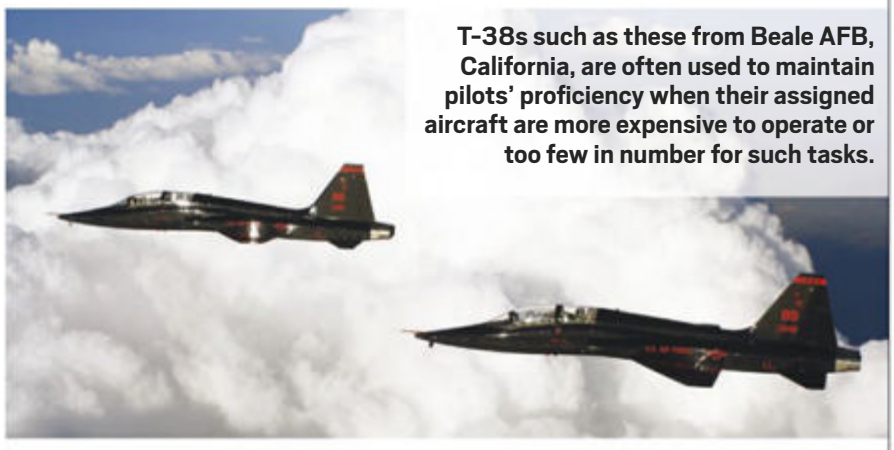
The contenders have shifted substantially for the T-X, as the Air Force's schedule repeatedly slipped. Alenia's M-346 was once thought to be leading the pack, along with what was then a BAE-led team with Northrop Grumman to propose a variant of the Hawk, as well as Lockheed/KAI's plans to move forward with the T-50. Alenia's strained bid with the M-346 is the only remaining foreign design.

The stakes are high, as 350 jets are needed to replace the T-38. A potential derivative program could total another 200 aircraft if the Air Force opts for single-track pilot training, using the chosen platform for advanced pilot training as well as advanced skills work, says Brig. Gen. Dawn Dunlop, director of requirements, plans and programs for Air Education and Training Command (AETC). The service could also opt for a "red air" version of the T-X; but both derivative decisions will come later.

The Air Force's delays to the so-called T-X were due to budget pressures, but also gave officials time to approach the requirements and procurement process differently, says Maj. Gen. Dwyer Dennis, director of global reach programs for the Air Force acquisition secretary. Typically, requirements are refined, validated and then handed off to procurement officials with little collaboration. With T-X, however, the teams were

working together to weigh the cost of various requirements against the capability required, Dunlop and Dennis say. They also engaged industry early and often about the requirements and potential cost tradeoffs. Though not unprecedented, the generals say the level of interaction with industry was unusual and beneficial.

"It has informed us on the state of technology—what is reasonable and what are some of the cost drivers—and it informed industry on what we really need," Dunlop says. These officials now feel more confident dealing with the thorny task of assessing how to score the forthcoming bids based on a set of threshold and objective requirements.



U.S. AIR FORCE/JOHNNY SALDIVAR

T-38s such as these from Beale AFB, California, are often used to maintain pilots' proficiency when their assigned aircraft are more expensive to operate or too few in number for such tasks.

The Air Force has made some serious missteps in this area in the past decade, most notably in the botched attempts to buy a KC-135 refueler replacement and the troubled path to procure a combat search-and-rescue helicopter.

Chief among the Air Force's concerns now is keeping costs down, specifically life-cycle cost, Dennis says. At the program's inception, industry was more focused on containing the development and procurement price. Recent budget pressures have, however, convinced the service to focus more on operating cost containment.

The Air Force has a cost cap in mind for the T-X, but Dunlop declined to share it. T-X includes not only the aircraft but also ground-based training systems and academic aids.

Likewise, these generals say the dialog has helped them to understand the cost impact of their requirements. For example, the service wants an aircraft availability of 80% for T-X, Dunlop says. The requirement for the T-38 is 75%; the fleet has not met that goal since 2011 and hovers below 60% now.

Feeding into aircraft availability are subordinate factors, each of which was reviewed for its cost implications. "We actually adjusted two of those parameters down lower that were in excess of our 80% aircraft availability."

One requirement adjusted based on industry input was for the cockpit's large-area display. While AETC's requirement is simply to ensure that the student pilot can handle tasks such as avionics management and sensor integration, industry proposed options that attempted to mirror the F-35's display.

"Originally, their selling point was, 'Look, it is the same as the F-35.' And I said, 'That is not important to me and my requirements.' What is important for me is that it is low-cost and that it meets the advanced pilot trainer mission task of teaching avionics integration, sensor management, cockpit management, . . . not necessarily that it matches a fifth-gen capability," Dunlop says. "Only through dialog and through their research did they come back and show us that it was a lower-cost solution that provided more adaptability for the long run."

The sustained g requirement was likely behind General Dynamics' decision to abandon the M-346. With a threshold of 6.5g and an objective of 7.5g, the performance level proved thorny for the aircraft's development. That stipulation was driven by 18 months of interviews with instructor pilots and research, Dunlop says. "That was very specific, because based on our discussion with instructor pilots [and] mission experts that was the minimum G we could accept that would allow us to meet the mission tasks of advanced pilot training," she says. Additionally, research found that 7.5g would be sufficient to ensure pilot students can operate at 9g, the upper extreme for most fighters. "If you can operate at 7.5g, you can operate at 9g," she tells Aviation Week.

Though this requirement is rigorous, it allows for the kind of performance needed for future F-35, F-22 and Long-Range-Strike bomber pilots. Once procured, she estimates—based on industry input and assessments of allied air force operations—the service could save 15% in operating costs annually for advanced pilot training, since the T-X's performance will reduce the need to use other platforms—such as the F-16 or F-15—to augment training for some skills. Fighters are much more costly to operate than the T-38 or the T-X. Dunlop says avoiding that follow-on training could save $160-280 million annually. Training hours will still be flown on the primary aircraft—F-22, F-16, F-15 and, eventually, F-35. But those hours will be dedicated to much higher-end skills than now, ultimately producing savvier pilots.

The T-38 cannot address 12 of 18 mission tasks needed today, Dunlop says. "Even if you gave me money to fix [these gaps], I can only fix one. And I can only fix one partially, and part of that is because I don't have the size, weight, power, cooling and growth margin available," she says. "I no longer teach what is known as air combat maneuvering in T-38s because it is so different than my fourth- or fifth-generation platforms today."

Also, the T-38 does not support any night-vision goggle training, which is handled in the formal units for fighter and bomber pilots. Formation flying outside of visual range—a tactic of fifth-generation flying enabled by covert data links—is not trained in the T-38 either. With T-X, AETC officials intend to incorporate actual or virtual data links to hone skills.

In addition, the T-38 lacks the ability for training in the use of "J-series" weapons, such as the ubiquitous Joint Direct Attack Munitions, they say. And it also falls short in training pilots for emergency procedures, which in fifth-generation aircraft are far more reliant on computer control than in the T-38. This work is transferred forward to the formal training units.

Dennis says the request for proposals is expected to be released in the fourth quarter of fiscal 2016, with a contract award in the fall of 2017. Initial operational capability is slated for 2023.

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King in Waiting

With first flight delayed, Sikorsky moves up ground tests to compensate

Graham Warwick Washington

Almost a year after roll-out, significant work remains before the U.S. Marine Corps' CH-53K King Stallion heavy-lift helicopter can take to the air. But once airborne, developer Sikorsky asserts that tests can move quickly because of work accomplished on the ground, and the Marines still anticipate initial operational capability (IOC) in 2019.

Two fully instrumented YCH-53K engineering development model (EDM) test aircraft will fly first, one shortly after the other, and Sikorsky says it can meet an operational test window to demonstrate the CH-53K's lift capability and allow funding to be released in fiscal 2017 for low-rate initial production.

The first aircraft, EMD-1, has begun ground runs at Sikorsky's West Palm Beach, Florida, development center, but must wait for the ground test vehicle (GTV) to complete key tasks before being cleared to fly. After 187 hr. of ground runs, the GTV is now idle, awaiting new gearboxes before finishing up the 250 hr. of tests required for flight clearance.

SIKORSKY AIRCRAFT

EDM-1, the first flight-test CH-53K, has begun ground runs.

Redesign and retesting of gearboxes after discovery of cracks during tests is the main driver of delays. The small nose, intermediate and tail gearboxes are now through qualification testing to 140% of the operational spectrum. The redesigned main gearbox is in testing and "proving out," says Mike Torok, CH-53K program vice president. "We are already building parts for the aircraft."

When the development contract was signed in 2006, first flight was planned in 2011. But the GTV—a full-up CH-53K anchored to the ground at West Palm Beach—did not begin ground runs until January 2014; EDM-1 rolled out in May. Now the Marines and Sikorsky say first flight is expected "this year."

But the program is not idle. EMD-1 began ground runs in February, reaching full rotor speed and 40-50% torque. Most flight instrumentation is installed. Next to fly, EDM-3 will be handed over to the flight center this month for final instrumentation and ground runs. These aircraft will be the primary drivers of the first part of flight test, expanding the envelope.

"We are making an effort to get as much of the software as we can in the aircraft before we fly," says Torok. "We have 95% of all functionality on the aircraft now. The last 5% is through the system integration laboratory and will be on the aircraft in the next month or two." After the delay, "we are in a better position to go to flight test with 100% functionality."

GTV testing has three phases. First is shakedown and envelope expansion, which "is effectively done, except for one or two extreme points," says Torok. Next is main-rotor whirl time, of which 44 of an anticipated 50 hr. have been completed. And finally, the pre-flight acceptance test, 50 hr. of "pure endurance running" in five 10-hr. blocks covering the operating envelope.

Qualification testing needed before first flight is 98% complete. The 2% remaining is finishing up a second round of testing dynamic components to failure. "Nominally we want to test two of everything to open up margin, and our target is to finish the second round before first flight," says Torok. "We will end up doing four rounds, the third and fourth staying ahead of the aircraft and giving us further life."

EMD-2 and -4 will be delivered to flight test by the end of the year. EMD-2 was pulled off the assembly line for overspeed and ground vibration testing then returned to finish its build. The first of six CH-53K system development test aircraft (SDTA) for operational evaluation is on the line at West Palm Beach. "It's the first of the 200 production aircraft," says Torok.

SDTA-2 is at Sikorsky's Bridgeport, Connecticut, plant in "Position 5"—where cockpit and cabin, main and tail rotor pylons, aft transition section and sponsons arrive from suppliers and receive modifications before moving to Florida for final assembly. "Aircraft 3 and 4 are queued up at the airframe suppliers on or ahead of schedule," says Torok.

The path to first flight involves completing qualification of the redesigned gearboxes, reassembling the GTV and finishing the remaining 70 hr. of ground runs. "In parallel, we will update the EDMs to the final configuration, then go for flight clearance," Torok says. To recoup some lost time, EMD-1 and the GTV are being used for testing that was planned for later in the program

A maintenance demonstration scheduled after completion of the pre-flight acceptance test was brought forward, and a cadre of Marine maintainers are on the GTV proving out the technical manuals. "That will save time downstream," says Torok. Also, while still on the ground, EDM-1 is getting a jump-start on avionics, communications and engine-start testing originally scheduled for later.

"We are working to mitigate the delays downstream," Torok says. EDM-3 has caught up with EMD-1 and "with both fully instrumented aircraft, we will get to the initial operational test window faster to support a production contract." This key test—demonstrating the CH-53K's ability to lift a 27,000-lb. load and carry 12,000-lb. 110 nm—is required for production approval. "We expect to be ready when the money is available. It's not exactly the way it was planned, but we have enough flexibility to keep things on target," he says.

"It's a normal development program, so you have discoveries," says Col. Hank Vanderborght, H-53 program manager. "Overall, it sits on a pretty solid technical foundation and is meeting the requirements the Marine Corps set for performance, survivability and supportablility. IOC is still 2019 and we have margin in the schedule and budget to meet that target," he says. "Support for the program is solid, and as long as it keeps tracking the support will remain."

Safer Approach

Easier, more accurate and repeatable carrier landings promise improvements

Graham Warwick Washington

New flight-control and guidance software for carrier landings will require a culture change within the naval aviation community if it is to deliver on its promise of easier, safer and more repeatable recoveries that reduce pilot workload and wear and tear on the aircraft.

U.S. Naval Air Systems Command (Navair) has completed land-based testing of the Magic Carpet software in the Boeing F/A-18E/F at NAS Patuxent River, Maryland, and shortly will begin at-sea evaluations on an aircraft carrier off the U.S. East Coast.

Tests show the new flight-control laws and head-up display (HUD) symbology provide the reductions in pilot workload that were predicted in simulations. The Magic Carpet software upgrades are slated to be fielded on the F/A-18E/F in 2018.

In a carrier approach, the pilot must maintain a glideslope angle to clear the stern of the ship and stay aligned with the centerline of the flight deck to keep the wings clear of the superstructure, but also control the angle of attack to within 1 deg. to ensure the lowered arrestor hook catches the wire.

The pilot manually follows optical glideslope guidance from the ship, controlling descent rate with power, airspeed with pitch attitude and heading with roll. But these control axes are cross-coupled, and maintaining glideslope, lineup and angle of attack requires constant throttle and stick inputs.

"If I make a small power correction, I change angle of attack, which affects glideslope, and at the same time I can drift off lineup. There are a lot of things going on," says Lt. Brent Robinson, test pilot with U.S. Navy evaluation squadron VX-23 at Patuxent River.

The F/A-18E/F also has an autothrottle approach mode, which attempts to maintain angle of attack. "When you make an aft-stick correction, the throttle will see the aircraft's nose come up and add power to maintain angle of attack, but fairly loosely," he explains.

The workload is a "little less," allowing the pilot to focus on lateral stick control to maintain lineup, but Robinson says only senior naval pilots are allowed to use the autothrottle mode. More-junior pilots are required to fly approaches manually to hone their baseline skills.

"I am primarily trying to hold glideslope, but to have the glideslope accurate I have to be on speed [angle of attack]. I focus so much on glideslope and angle of attack that my lineup ends up drifting. It takes a lot of practice to build up the muscle memory to do the corrections," Robinson notes.

In Magic Carpet, gains and settings in the digital flight-control computer are fine-tuned to hold angle of attack tightly while longitudinal and lateral stick inputs are decoupled. "The primary factor in glideslope is longitudinal stick and in lineup it is lateral stick," he says.

The control system melds aileron, stabilator and rudder control to maintain attitude. Then the flaps are raised a few degrees from their nominal half or fully deployed position. This gives the control system a few degrees of flap movement to use for direct lift control.

"With aft stick, the flaps lower slightly to increase lift, the stabilator balances pitch, and I get almost pure vertical movement because angle of attack is being held for me. Near-pure lift increase or decrease gives me very high-fidelity control over glideslope," Robinson says.

The flight-control computer also calculates and maintains the ideal glideslope—3.5 deg.—using sensed windspeed and ship speed, either estimated by the pilot from the carrier's wake or called out by the landing signal officer on deck.

If high or low, the pilot can make a longitudinal stick input, hold it until centered on the optical guidance "meatball," then release the stick, and the aircraft will return to the ideal glideslope. "Now I have fine control available. I need to make much less input," he says.

The new glideslope-holding flight-control law is called Delta Path. Magic Carpet also includes a "Rate" mode, which holds flightpath command and not glideslope. This is for use in the pattern and holds bank angle and pitch attitude in the turn to intercept the glideslope.

The other part of Magic Carpet is new HUD symbology that ties the flight control changes together. This in-

U.S. NAVY

F/A-18E/F pilots must maintain an 8.1-deg. angle of attack to ensure that a tailhook catches deck wires.

cludes a horizontal line drawn 3.5 deg. down from the horizon. If this is close to the optical guidance cue from the ship, Robinson explains, the aircraft will be near the required glideslope.

The bigger piece of the new symbology is the ship-referenced velocity vector. "This is referenced to the ship by basic geometry from the ship speed, and if I put it on the centerline and hold 3.5-deg. glideslope, I will land on the centerline," Robinson says.

Simulator and flight tests indicate that, of the decrease in pilot workload and increase in the accuracy and repeatability of landings from using Magic Carpet, three-quarters come from the flight-control changes and a quarter from the HUD symbology, he continues.

Navair has completed land-based testing of Magic Carpet, flying carrier approaches from nominal to extreme off-nominal to a shore-based field with the aid of an optical guidance system and landing signal officer.

"We have tested and refined the gains and feel they are as good as we can get them," says Robinson. Six pilots were involved, only two of whom had experience with Magic Carpet. "The real-life performance is very close to the simulator, which shows our models are correct and the design is holding up."

Land-based testing involved some "pretty extreme cases we will not perform at the ship, where we will run a bunch of nominal approaches to build up a touchdown dispersion database" as well as some less-extreme off-nominal approaches, Robinson notes.

"When Magic Carpet comes to the fleet in the next few years, there has to be a large cultural change for pilots," says Robinson. "We are attempting to make this the primary mode of landing and to make manual and

New Blood

Russia may see China as a candidate for future human-space cooperation

Frank Morring, Jr. Washington

NASA/BILL INGALLS

NASA Administrator Charles Boldin (right) met Igor Komarov, his counterpart at Roscosmos, as their two agencies launched a U.S.-Russian long-duration crew to the ISS.

An ambiguous statement by Russia's new space chief suggests NASA's human-spaceflight partner may be ready to work with China on exploration projects after the International Space Station's 2024 expiration date.

NASA Administrator Charles Bolden says remarks by Igor Komarov, the new head of Russian federal space agency Roscosmos, probably meant Russia supports adding China and other "non-traditional" nations to future human spaceflight cooperation.

Komarov's remarks, and Bolden's response, came after a meeting at Baikonur Cosmodrome as their two agencies launched a 342-day mission to the ISS. Some Russian reporters interpreted the remarks as suggesting the two space leaders discussed building a joint follow-on to the station, but both indicated that was not the case.

"Fundamental research and Moon and Mars missions are very expensive," Komarov said in a March 31 interview with the Russian newspaper *Rossiyskaya Gazeta*. "We can solve many more tasks if we act together and save our budgets. There is a common understanding that international cooperation should go on.

During a question-and-answer session after a speech to the Aero Club of Washington on March 30, Bolden said he did not discuss China with Komarov and stressed that NASA is "the only federal agency with a congressional prohibition against bilateral activities with China."

"My impression of it was, to be quite honest, that was probably what he was talking about when he talked about opening the field of exploration to many countries," Bolden said. "My comment when he said that was that's what the president asked me to do when I first became the NASA administrator" by expanding cooperation with "non-traditional partners."

NASA issued a carefully worded statement after the meeting at Baikonur, where NASA astronaut Scott Kelly and Roscosmos cosmonaut Mikhail Kornienko took off on an unprecedented joint mission to gauge effects of long-duration spaceflight on the human body, with up-to-date medical equipment and protocols.

"We are pleased Roscosmos wants to continue full use of the International Space Station through 2024—a priority of ours—and expressed interest in continuing international cooperation for human space exploration beyond that," NASA stated. "The United States is planning to lead a human mission to Mars in the 2030s, and we have advanced that effort further than at any point in NASA's history. We welcome international support for this ambitious undertaking."

Bolden described the talks with Komarov as "one of the most invigorating meetings that I've ever had with one

autothrottle approaches obsolete."

Presently, competition between pilots is a major factor in improving their manual-approach flying skills. "We make it competitive. It's part of the learning curve, of staying sharp. Everyone wants a better score," he adds.

"With Magic Carpet we will lose that competitive edge, but it will be far more safe and repeatable and will make it easier on maintaining the jets and the aircraft carriers," Robinson concludes. "But it will be hard to change the mindset. I expect it will start out slow and be phased into the fleet."

of my counterparts from Roscosmos."

A former industrial manager who was deputy director of Roscosmos, Komarov had been in the top office less than a month under a reorganization that expands his authority to include the commercial enterprises that build Russian space hardware.

"Part of it is unfortunately a blast from the past, where almost everything is under a single organization and belongs to the state," Bolden says. "But my counterpart now is responsible, not only for the Roscosmos space agency but also . . . for industrial development of rockets and the like, and even more important, actually has control of the institutes and medical organizations that are looking at medical research. The good part is he himself is an industrialist; he's a businessman with no experience in space, with very forward-leaning ideas."

Bolden said he also took heart from the return of former Roscosmos chief Yuri Koptiev, who helped set up the U.S.-Russian ISS partnership after the Soviet Union collapsed, as a senior adviser to the Russian agency, with support at the top of the government.

Despite the sometimes harsh rhetoric from that government, the two nations say they will continue close cooperation on the ISS until 2024. In addition to the long-duration mission, NASA plans to buy more seats on Soyuz vehicles that have provided the only route to the ISS since the space shuttle was retired in 2011 and to work them into the mix with the planned U.S. commercial crew vehicles scheduled to begin flying by the end of 2017.

BLUE ORIGIN PLANS SUBORBITAL TESTS

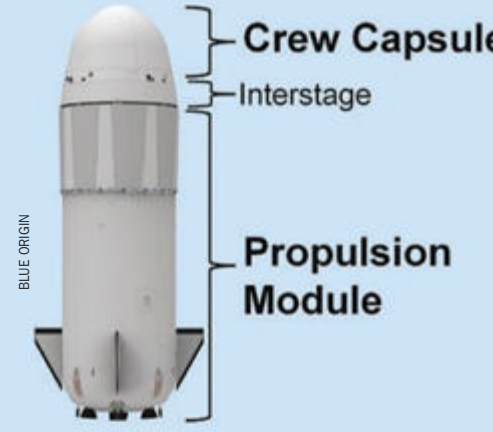
Frank Morring, Jr. **Washington**

Blue Origin has completed acceptance flight tests of its cryogenic BE-3 deep-throttle engine, and plans to begin autonomous flight tests later this year with the reusable New Shepard suborbital human spacecraft it will power.

Rob Meyerson, president of the secretive company bankrolled by Amazon founder Jeff Bezos, told reporters on April 7 "we're probably a few years away from selling tickets" on New Shepard, but the completion of acceptance testing was a big hurdle to clear.

The 110,000-lb.-thrust engine can be throttled down to 20,000 lb. thrust for a vertical landing, Meyerson said. New Shepard testing at the company's facility in West Texas will begin in autonomous mode, with Blue Origin crew eventually occupying the vehicle's three seats for the initial push to 100 km.—the traditional altitude where space begins.

Ultimately paying passengers will fly from the Blue Origin site in Van Horn, Texas, either for tourism or research. The vehicle's booster will lift them to the suborbital altitude before flying back to a tail-down landing at the launch site. The crew capsule will separate and return to the same facility via parachute, after providing about 4 min. of microgravity to its passengers and experimental payloads, Meyerson said, declining to announce a price for the service.



Concept of Blue Origin's reusable New Shepard human spacecraft, which is set to begin tests aimed at suborbital flight next year.

Flight-testing the New Shepard also will allow the company to build time on the BE-3, a liquid-oxygen, liquid-hydrogen-powered engine that the company plans to upgrade as a commercial product designated BE-3U for upper stage use. That will require a larger nozzle and other changes.

"To make the BE-3 into a BE-3U, the simplest change could be a large expansion ratio nozzle, which is designed to operate at altitude," Meyerson says. "But there will be other changes we'll make as we fly the BE-3 in our suborbital flights. We could theoretically with our plans have dozens if not hundreds of flights with the New Shepard vehicle with the BE-3 before we fly an upper stage BE-3U. So we could do performance improvements if our customer base needs that."

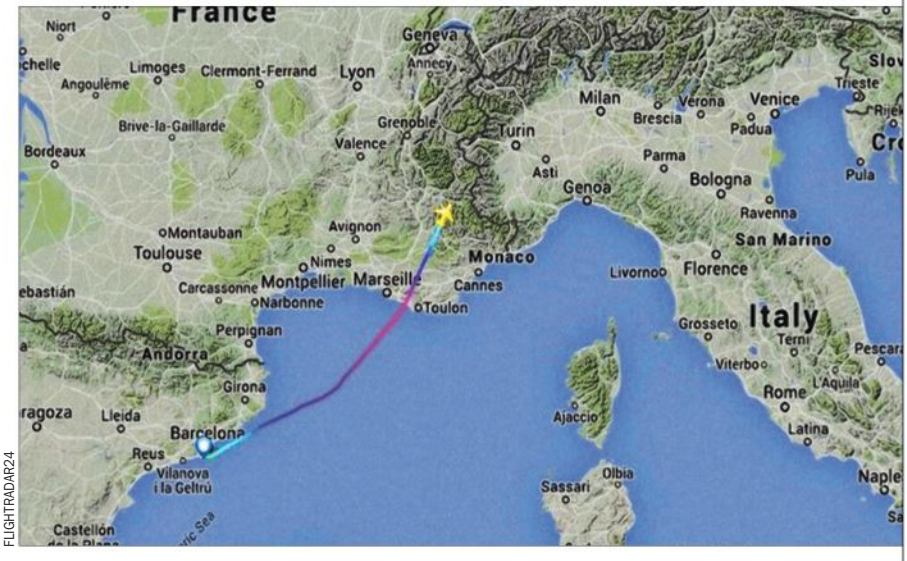
That base could include United Launch Alliance, which has said it will buy Blue Origin's BE-4 hydrocarbon-fuel main-stage rocket engine for its next-generation launcher. That engine is in testing at the component level—the power pack and a subscale injector—and is on schedule as a rapid follow-on to the Russian-built RD-180 engine, with full-scale testing set to begin next year, according to Meyerson.

"The BE-4 is a first-of-its-kind engine to be developed in the United States," Meyerson says. "It uses liquefied natural gas to produce 550,000 lb. of thrust. The BE-4 offers the lowest cost and is the fastest path to production for an American-made engine. The engine is more than three years into development, and we're now on track to conduct full engine testing in 2016 and complete development of the engine by 2017, two to three years ahead of any other alternative engine that's out there."

ADS-Bonus

Auxiliary data boosts ADS-B's value as an active, forensic tool

John Croft Washington



A chance download of auxiliary data from three ground-based receivers in crowd-sourced surveillance provider Flightradar24's European network yielded a defining moment in the final minutes of Germanwings Flight 9525 on March 24, and it is potentially a new source of forensics data available for the accident investigators.

Cloaked in reams of stored Automatic Dependent Surveillance-Broadcast (ADS-B) Out data that Flightradar24 technicians downloaded 90 min. after the crash and deciphered two days later, there was a change in the aircraft's autopilot-commanded altitude from cruise flight at Flight Level (FL) 380 (approximately 38,000 ft.) down to 100 ft., the minimum the system will accept. Based on an initial review of the aircraft's flight data recorder after it was found on April 2, the French aviation safety agency, BEA, on April 3 confirmed that the "pilot present in the cockpit used the autopilot to put the airplane into a descent toward an altitude of 100 ft." and increased the vertical speed command to the autopilot several times during the descent to increase the vertical speed.

Commanded altitude is one of many so-called Downlink Aircraft Parameters (DAP) that can be included as auxiliary information from ADS-B Out avionics, but the data today is not considered part of the primary 1090-MHz Mode S extended squitter surveillance stream that is rebroadcast and recorded. The primary data, meant to mimic radar coverage, includes aircraft identification, position and speed.

Mikael Robertsson, Flightradar24 cofounder, says primary ADS-B data comprises only 5% of the information it captures every 4-5 sec. from its more than 6,200 receivers in a global network. "It is a lot of extra information we normally don't upload," he says of the other 95%, which includes DAP data. "We save it in the memory of the receiver, just in case something happens."

Along with commanded altitude, there are a growing number of auxiliary ADS-B parameters—commanded and vertical speed, roll angle and magnetic heading among them—being eyed for dozens of advanced safety and efficiency applications. European air traffic controllers are among the first to begin experimenting with the use of the auxiliary data for enhanced safety.

The change in Flight 9525's commanded altitude is a key forensic finding when coupled with a French criminal prosecutor's assertion, based in part on the recovered cockpit voice recorder, that the aircraft's co-pilot purposefully locked the captain out of the cockpit and descended the aircraft into the ground. If true, it supports the BEA statement that alludes to the co-pilot using the altitude input to command the Airbus A320 into the fatal dive. Flightradar24's analysis of the DAP data shows that seconds after the altitude command was input, the A320's continuous descent began.

Robertsson says the BEA contacted his company 45 min. after the accident, requesting the ADS-B data. "We sent them the data 2 hr. later."

Stored in three Flightradar24 ground-based ADS-B receivers were details on the pilot inputs in the Germanwings Flight 9525 cockpit before it crashed.

Europe is testing DAP parameters including barometric pressure (QNH) and commanded altitude that pilots set in the cockpit. With QNH in hand, controllers can compare it with the actual barometric pressure in cruise or at a landing site to ensure the pilots set the instrumentation correctly. For commanded altitude, controllers can compare the value the pilots set against the assigned altitude to catch errors or misunderstandings about clearances. It is not clear in the case of Flight 9525 if DAP data were collected and stored by the European radar sites that capture the primary ADS-B data. In the U.S., auxiliary data is currently not used by controllers nor is it saved.

For Flightradar24, capturing the auxiliary data was a race against the clock, as a receiver's memory fills up in 4-5 hr. and is overwritten with fresh data. Built by Germany's Gunter Kollner Embedded Development, the receivers have an SD (secure digital) card that can store weeks or months of data; however, Flightradar24 had disabled the memory storage option several years ago as the SD card's life limits were too short. That leaves only the receiver's internal memory for storage, a capability the company is attempting to increase by a factor of 2-3 through compression techniques.

Robertsson says a technician was able to connect to the three receivers near the French Alps impact site approximately 90 min. after the crash and download the data of interest. The capture represented the first successful download of the auxiliary data after an accident. Two earlier tries did not pan

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out. In March 2014, when Robertsson learned that Malaysia Airlines Flight 370 was missing, 6 hr. had passed since the aircraft's diversion from its course, and a receiver in the vicinity had overwritten data from that flight. The company also made an attempt to download stored data on a receiver in the Ukraine in July 2014 following the shoot-down of Malaysia Airlines Flight 17, but the receiver "crashed before we managed to download the data," says Robertsson. "[The] Germanwings [crash] was the first time we really managed to get the data in time."

Using ADS-B documentation and signal specifications, Flightradar24 technicians decoded the stored data, fo-

Peace Treaty

Middle ground is emerging for electronic flight bags and tablets in the cockpit

John Croft Milwaukee

When American Airlines became the first U.S. carrier to gain FAA approval to use iPads for all phases of flight in 2012, other airlines quickly followed suit. The clamor for a low-cost, off-the-shelf, consumer-grade portable tablet for electronic documents and charts appeared to sound the death knell for the heavier, vastly more expensive installed electronic flight bags (EFB) that had been filling that role for more than a decade.

Fast-forward three years, however, and the legacy EFB industry has not only remained solvent but has morphed into what likely will be an essential element in the next-generation cockpit for older-generation jets. The rebirth is being kindled in part because EFBs can be a lower-cost alternative platform to run NextGen applications such as in-trail procedures or to meet mandates—including controller-pilot data link communications—and also because EFB providers have diversified into offering server systems that tap into aircraft data and provide secure data storage.

"Tablets themselves do certain things exceedingly well," says Chad Cundiff, president of Astronautics Corp. of America. "But there are gaps and struggles for the airlines—maintaining the configuration, losing them, breaking them, getting them stolen, making sure they have what you need to have on them."

Configuration control aside, giving tablets access to aircraft data broadens the portfolio of available applications to include airport moving maps, satellite weather, electronic technical logs and route profile optimization for fuel savings and other "non-certified" applications, along with the standard electronic document and static charts.

But the devices cannot be used to run applications that pilots use for communicating with controllers via data link or navigating the aircraft. That rules out NextGen routines based on Automatic Dependent Surveillance-Broadcast (ADS-B) In capability, with which airlines will likely equip in the future. Although not mandated, the business case for NextGen is largely dependent on airlines voluntarily equipping with ADS-B In to take advantage of safety and fuel- and time-saving processes that include in-trail procedures, interval management, merging and spacing, and surface management. Higher-end EFBs can be used for those tasks, however, leading many airlines to consider a mix of installed and portable devices.

As evidence of the staying power of the reinvented EFB, one of the newest single-aisle commercial airliners, the Bombardier CSeries, has a factory option for dual 12.1-in. touchscreen EFBs built by Esterline CMC Electronics, even though the new cockpit is already equipped with five 15.1-in. displays belonging to the most advanced Rockwell Collins integrated avionics suite available. Also an option is CMC's Aircraft Information Servers (AIS).

Why? CSeries Vice President and General Manager Robert Dewar says some airlines want to standardize across fleets that already have installed EFBs.

BOMBARDIER

CMC's 12.1-in. Class 2 PilotView EFBs are factory options as side displays on Bombardier's new CSeries single-aisle airliner.

cusing on the QNH value of 1006 mbar, which was the barometric pressure at Barcelona, Spain, when the aircraft departed. Robertsson says QNH is always paired with commanded altitude in the data stream, and commanded altitude could be compared against tracking data from earlier in the flight. He was not yet sure why the QNH setting remained the same during the flight, as pilots would be expected to enter a standard pressure of 1013 mbar during cruise at FL380. He says two A320 pilots who viewed the data believe the QNH was set for the departure airport and not updated, an assertion made stronger by the BEA's verification of the commanded altitude change.

But there is also a future-proofing aspect of the nascent ADS-B In application. While those new applications could be hosted in the forward panel, "you'd have to pay fees to the integrated avionics companies," says Dewar. Legacy EFB providers have a slight edge because their systems are not in the forward field of view of the pilot and hence can be less costly to update, even though the devices can be certified as an additional avionics display. That makes the EFB an ideal candidate to host NextGen applications, which are evolving and progressing as ADS-B Out surveillance comes into force via mandates globally, and airlines, albeit slowly, begin purchasing ADS-B In equipment as well.

New models for software security are also giving traditional EFBs more flexibility. The Astronautics Corp. of America's Nexis Flight-Intelligence System has software-only partitioning that allows operators to have certified and non-certified (consumer) applications running simultaneously in the same side display unit. The non-certified side can often be updated or loaded with no recertification, reducing costs and giving airlines the freedom to write their own applications. "On the forward display, no one is going to let you touch that code," says Cundiff. "If you want a change, you have to go back through the [original equipment manufacturer] and decide on a certification plan. The bill you get at the end is going to have a lot of zeros on the end of it."

While debate continues about the form and function of the ultimate solution, EFB providers see a new middle ground emerging where tablets, largely iPads and Microsoft Surface models, can work in tandem with modernized EFBs and servers to gain a holism for efficiency on flight decks. Many airlines are considering a phased approach, starting with tablets and servers and evolving into tablets, servers and EFBs when ADS-B In applications mature.

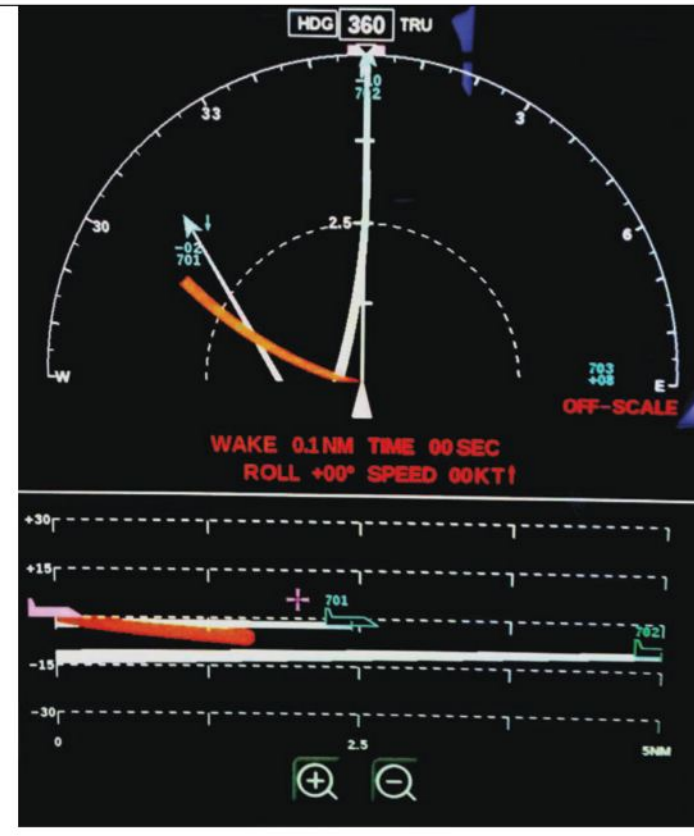
The FAA is evolving its stance as well and is expected to better align its EFB nomenclature with the European Aviation Safety Agency in new guidance to be issued potentially as soon as May. EFBs are currently categorized as having a hardware class (Class 1 is portable, Class 2 is partially connected, and Class 3 is used as a multifunction display) and a software type (Type A for electronic documents, Type B for charts and Type C for avionics-grade applications). Under the new designations, there will either be portable EFBs that run Type A and Type B software or fully certified installed EFBs that have software partitions to run certified and non-certified applications.

Three main EFB providers in North America offered a snapshot of how each is handling the emerging new models.

UTC Aerospace Systems (UTAS) has approximately 100 Class 3 EFBs in operation and another 1,000 Class 2s, but its current focus is largely on selling interface and server equipment to allow airlines to use their thousands of tablets for efficiency applications, effectively making the devices Class 2 EFBs. They do that by installing tablet interface modules (TIM) to supply power and a data connection, either wired or Bluetooth, between the tablet and an Aircraft Interface Device (AID), a server that taps into aircraft data. "The majority of our focus is the tablet-based market, and the tablet interface seems to be where the energy is," says Jim Tuitt, UTAS director of business development. "We have a growth-path strategy with tablets—start with power and grow to more connections, all the way up to a purpose-built UTAS SmartDisplay (EFB) that can be used for satellite communications and an Aircraft Communications Addressing and Reporting System (ACARS)."

Tuitt says the path gives customers options to "grow into the system they need," a path that is less risky because tablets cost less than EFBs. "This allows airlines to install a certified ADS-B-In-capable system a little bit farther down the road, when standards and concepts of operation are better defined," he says. "All the apps for efficiencies can be done with a tablet today."

United Airlines has selected the TIM for its Airbus A320 fleet initially, but has not yet made a decision regarding its Boeing 737 and 777 models, says Tuitt. UTAS certified the



JOHN CROFT/AW&ST

Astronautics Nexis Flight-Intelligence System is designed to augment the forward flight deck, hosting advanced ADS-B In applications that could include wake turbulence avoidance (pictured).

A320 modification in May 2014 and installations are underway. When rolled out across the fleet, the 12,000 pilots that United equipped with company-bought iPads will have access to a broader number of applications, including inflight satellite weather. Tuitt says airlines are interested in having more users interact with the systems as well, including maintenance teams and flight attendants who could use tablets and the server to enter galley or seat issues into a technical log.

Although the lack of a software certification level precludes the tablets from being used for NextGen ADS-B In applications, Tuitt says the installed hardware can be the first step toward a solution that will include an installed EFB, preferably the company's G500 or G700 SmartDisplay EFBs, when the carrier needs ADS-B In applications. Tuitt says the G700, UTAS's newest EFB, has the "look and feel" of an iPad, with capacitive-based pinch and zoom and hand-rotation input. The company's earlier EFBs use resistive touch. "The feedback from customers was that they want to interact with the EFB the same way they would with an iPad or Microsoft Surface tablet," says Tuitt.

UTC AEROSPACE SYSTEM

UTAS's Tablet Interface Module, pictured here on a Boeing 737NG, allows pilots to connect their iPads with onboard communications for own-ship position, satellite weather and other applications.

CMC is also putting heavy emphasis on installed Aircraft Information Servers (AIS) that will allow airlines to get the most out of their low-cost tablets while promoting its multi-touch capacitive EFB displays. "We're challenged by the advance of tablets; we have to recognize it," says Jean-Marie Begis, product line director for EFB and aircraft wireless systems at CMC. "On the other hand, we're able to enable those tablets with application servers that will satisfy a number of regulatory but also practical requirements such as updates, control and configuration of software."

One very practical consideration for installing a server is that when crews lose or break their tablets, the server—which has all the updated content—can be used to download the needed material onto a new device. CMC says its AIS products, part of the PilotView Crew Information System, are "getting good traction overall," particularly a new compact, flange-mounted AIS that is located in the aircraft's avionics bay and works wirelessly with tablets that can mimic many EFB functions. Those functions can include charting, electronic documentation, en route real-time weather moving maps, terrain awareness, camera surveillance, and aircraft data monitoring and reporting. A managed network switch segregates data flowing to the cockpit, cabin and maintenance users. AIS uses the "latest and greatest" secure network technologies, in part from the banking industry, says Begis.

The company's 12.1-in. display size has brought a lot of unexpected interest from different markets, says Begis, with part of the popularity owing to the display's capacitive-based multi-touch capability. Like UTAS, CMC's legacy screens use resistive technology (the company has 4,000 EFBs in the field) but Begis says multi-touch is now seen as a basic requirement in the requests for proposals (RFP) it receives from airlines.

Astronautics is focused more on smaller (6 X 8-in.) touchscreens that are fully integrated (Class 3) to the aircraft with its Nexis family of products, first certified in early 2014. Launch customer Virgin America is in the process of installing the systems on its A320 fleet, to be completed in the first quarter of 2016. Included in each aircraft are two resistive-based multifunction displays and two servers. The company has delivered more than 1,000 EFBs and is the forward-fit provider for Class 3 EFBs for Boeing's widebody fleet. Engineers are researching multi-touch capability and other human-machine interface modalities, including gesture and voice. The capabilities will not likely come with a large-format display. Cundiff says the prototype 17-in. display "did not sell well."

RFPs from airlines typically include options for servers that connect to tablets, servers that connect to tablet docking stations and "full-on EFBs," says Cundiff. The company has solutions that fit each need, but Cundiff sees the most long-term benefit from Class 3 capabilities. "Airlines like the functionality [the tablet solutions] bring, but if they get to the point [of] doing ADS-B In, they're not going to do that on a tablet," he says. "Then they start looking at what is the right architecture for the future." The ultimate architecture is a work in progress.

"Everyone is trying to make sense of it," says Cundiff. "Right now, we're trying to stay fairly agnostic. If you want to run your airline with a set of tablets, then take the flight server. You can wirelessly connect your tablets, you can get information in and out of the avionics system. You can network the maintenance guys with the pilots and with the crewmembers. You can upload and download information; you can store flight-critical information on the server so if the Surface becomes wiped, you can rewrite it before you fly."

Along with allowing for NextGen applications, an installed EFB has other values, says Cundiff. "You do not have to worry about the flight crew forgetting it, and it is a low-cost way of getting some of that NextGen functionality as opposed to putting it on the forward displays, where retrofit can be pricey."

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Contents

Unlocking Value

It's the ability to transfer data into information

Like many of you, I suffer from information overload. As much as I like to stay informed, sometimes streaming information and 300 daily emails can feel like clutter.

So how do we distill it to focus on what's important? The trick involves knowing when to add or subtract.

Look at our MRO of the Year Award winners (see page MRO4). Three of our winners—AFI KLM Engineering & Maintenance, Haeco and Kuehne+Nagel—added capabilities but bundled them to simplify the aftermarket for their customers. Another winner, Nordam, reduced the complexity of F/A-18A-D engine bay doors by eliminating the unique fastener pattern of each door and creating one configuration to streamline the repair process.

At the Aeronautical Repair Station Association's annual symposium in mid-March, FAA Administrator Michael Huerta stressed that the agency supports eliminating redundant MRO safety audits and is implementing risk-based approaches to deliver improvements to the system—so less is more. Actions such as this shift resources to higher risk areas, "which means we're not treating everyone and every problem the same," he says. For front-line inspectors who follow black-and-white checklists, "now we're asking them to evaluate shades of gray, which can be hard for people to work through."

Streamlining isn't always easy. But in the case of technology, it might be.

Several industry executives with whom I've spoken recently have emphasized that technology has reached an inflection point—and our industry should soon see data distillation in more meaningful ways.

Take Rockwell Collins, which for years has provided information enablement, from routers to avionics, but now can transmit flight-critical information during flight—instead of aggregating it after landing. "We see a logarithmic need to pipe more information" for efficiency and safety across the aviation ecosystem, says Kent Statler, the company's executive vice president and chief operating officer. But it's not just piping the information. "It's the ability to transfer data into information—that is where the value of the data is unlocked," he says.

During our conversation, he revealed that Rockwell Collins plans to leverage apps and services on top of the data—or even offer a subscription-based business warehouse. Similar to Apple, which itself does not offer a lot of apps—"it provides the secure highway—and developers pay a license," says Statler.

Don't be surprised if Rockwell Collins moves into this space within the next year.

Matthew Bromberg, Pratt & Whitney's aftermarket president, also believes the industry is at a turning point with data and discusses on page MRO50 how the OEM is working with IBM on intelligence workscopes. "We built a model with IBM that can predict inflight shutdowns to a 99% accuracy, looking forward 12 months," says Bromberg.

All of these business examples identify one thing: unlocking value. Whether you add or subtract to get there isn't as important—but getting to the value proposition is.

—Lee Ann Shay

Follow Aviation Week's coverage of our MRO Americas and MRO Baltics, Eastern Europe and Russia events on **AviationWeek.com/mro**

The next issue of the MRO Edition will be dated May 25-June 7.

Keep up with Shay on **MRO's** *blog:* **AviationWeek.com/mro** *and on Twitter:* **@AvWeekLeeAnn**

MRO of the Year Winners Are . . .

A common theme is providing a deeper level of support

Lee Ann Shay Chicago

The 2015 winners of Aviation Week's MRO of the Year awards exemplify excellence in establishing high-tech services for next-generation aircraft, integrating cabin life-cycle services, delivering reliable engine transportation and logistics, and crafting engineering solutions to improve efficiencies and save costs. Our 2015 honorees—Air France Industries KLM Engineering & Maintenance, Haeco, Kuehne+Nagel and Nordam—provide examples of how creative aftermarket solutions deepen service value for customers. Aviation Week will present awards to the four winners, along with the Lifetime Achievement Award to Ernesto Ruiz, at a ceremony at Aviation Week's MRO Americas Conference & Exhibition in Miami on April 14.

Outstanding Airline Maintenance Group

Air France Industries KLM Engineering & Maintenance took several major steps in 2014 to set up comprehensive support for the latest generation of aircraft and engines—including establishing maintenance programs for the Airbus A350 and Boeing 787. Some of the specifics include establishing an agreement with General Electric to become the first non-OEM shop to perform quick-turn shop visits for the GEnx engine, completing the first Engine Alliance GP7200 full-shop engine visit, and developing 787 engine nacelle and APU repair capability. By establishing next-generation capabilities such as these, AFI KLM E&M brings to the market adaptive solutions—including aircraft-on-ground (AOG) services, parts pooling, integrated supply chain, engine repairs and asset management solutions. Its order book grew 20% in 2014.

Leading Independent MRO

As part of its long-term growth strategy and to compete its service spectrum in the cabin business, Haeco acquired Timco Aviation Services in February 2014. Not only did this expand Haeco's operations into North America, but the companies used the opportunity to create a sub-brand, Haeco Cabin Solutions, which saves airlines money by offering full-service cabin integration and reconfiguration services for narrowbody and widebody aircraft. This is possible because Haeco Cabin Solutions covers solutions for the entire cabin life cycle—including design engineering, seat and cabin component manufacturing, cabin completion and reconfiguration, ODA certification, and line and heavy maintenance. The one-stop shop capability helps expedite turnaround times and promotes effective resource planning.

Innovative Supplier/ OEM Service Provider

Kuehne+Nagel created an innovative end-to-end integrated supply chain solution for transporting engines: KN EngineChain. The company realized that regulations and certifications did not address the transport of aero engines—an activity that can lead to damage and delays of these assets typically valued at $1 million-30 million. Kuehne+Nagel created a training program for their employees and carriers to handle engines—as well as a certification program to assess and evaluate carriers handling engines. Then the company integrated this into its global network operations, which include a Web portal, AOG desks, and sites, so it is part of Keuhne+Nagel's standard operating procedures. A customer said this service has provided greater control over transport movements, time savings, logistics savings, and reduction of in-progress inventory and associated carrying costs.

Military Center of Excellence

Nordam is reducing AOG time for U.S. Navy F/A-18 Hornets by providing interchangeable, remanufactured engine bay doors that feature new skins and blanked-out edges. Each aircraft features six engine bay doors to give mechanics access to the General Electric F404 engines, but each door has a unique fastener pattern due to manufacturing and maintenance variations. This dictated that each door had to be removed, overhauled and returned to the same aircraft. Nordam tackled this inefficiency by submitting an engineering change proposal to the U.S. Navy and Marine Corps to perform all life-extension repairs on the Hornets and create a universal configuration so the doors fit on any of the aircraft. This repair solution means any Navy maintenance unit can order the universal door from the Navy supply system, have it match-drilled to the recipient Hornet and installed at the aircraft's location. The damaged engine bay door then can be returned to Nordam for repair if stock levels dictate. This optimizes aircraft downtime, makes the maintenance process more efficient and improves fleet supply chain management efficiencies.

Lifetime Achievement Award: Ernesto Ruiz

Ernesto Ruiz is chairman of Aeroman, a leading narrowbody MRO provider and the only founding member of the Airbus MRO Network in Latin America. With more than 27 years of experience in senior leadership positions with TACA Airlines and Aeroman, Ruiz has played a fundamental role in the turnaround of Grupo TACA as well as in Aeroman's incursion into the North American market. Ruiz began his career with TACA as general manager for Aeroman, the company's MRO division at the time. He became TACA's director of maintenance and engineering, then was promoted to vice president-maintenance and engineering for Grupo TACA, doing double-duty as Aeroman's GM. Some of his key assignments were developing, selling and managing the heavy maintenance services for third-party customers, and coordinating, at the same time, all maintenance and engineering support to Grupo TACA's fleet.

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EMMC Priority

Maintenance group refocuses to address key AD process improvements

A4A EMMC Chairman Mike Arata

UNITED AIRLINES

Mike Arata, United Airlines managing director of engineering

During the past six months, the Airlines for America Engineering, Maintenance and Materiel Council (EMMC) has refocused its energies on addressing a smaller population of key process improvements that have a high impact on all airlines. One of the major ones involves working with the FAA on managing airworthiness directive (AD) exceptions.

As background, in August 2011, the FAA released the final report for the Airworthiness Directive Aviation Rulemaking Committee (AD ARC), which was the result of many months of effort among industry leaders to refine the AD process.

The overarching goal of the committee was to identify enhanced procedures for the development of AD requirements and technical instructions, with the expectation that safety aspects would be improved as well. The recommendations from this committee yielded new or revised FAA and industry guidance, as well as the release of agency policy memoranda on specific AD process issues.

NIKLAS BILDHAUER

The volume of Alternative Methods of Compliance for airworthiness directives is still high and can lead to the inefficient use of FAA and industry resources.

Since the release of the new guidance, the FAA, aircraft operators and OEMs have been working to implement these procedures within their businesses. Some of the more notable changes were the introduction of Required for Compliance (RC) elements into the service bulletin instructions authored by the OEMs, an enhanced lead airline process under ATA Spec 111 and best practices for operators to maintain AD compliance under Advisory Circular 20-176. The improvements are yielding better service bulletins and a reduced need for Alternative Methods of Compliance (AMOCs) to cover technical corrections within the OEM documentation. When required, AMOCs represent a cumbersome and inefficient use of valuable FAA, OEM and operator resources.

The benefits of the process improvements from the AD ARC will continue to take hold as new service bulletins are issued with the RC elements as standard protocol. However, the volume of AMOCs continues to be high, as operators are still implementing ADs that were not written under the new guidance. Recognizing that most of these enhancements are forward-looking, we continue to look for ways to apply the same methodology in reverse for the handling of minor deviations to the ADs.

In the absence of RC elements within older bulletins, operators are obligated to pursue an AMOC for any variance to the specific language for all steps.

To enhance the management of AD exceptions, the EMMC is focused on using the current methodologies that were approved by the FAA through the AD ARC, and applying them to the management of variations that continue to be identified through incorporation of ADs. With Boeing as a key partner in developing its own internal procedures for risk assessment of incoming requests, we are collectively starting to see possibilities for a path forward to drive down the need for AMOCs. The mechanisms within the FAA and Boeing to implement the "RC assessments in reverse" are still being ironed out, but there is clear alignment on the opportunity to chip away even further on the high volume of AMOCs.

The AMOC reduction strategy is an example of where the EMMC continues to see opportunities with the FAA to identify business processes that can be streamlined to benefit operators and the agency, but also drive safer products for the industry as a whole. With the recent inclusion of safety management concepts into every part of the airline business, the collective energies of its partners can focus on the chances for safety improvements versus the commitment of resources to the sometimes cumbersome administrative aspects of existing processes.

Using the AD exception management process improvements as a template, we hope this will trigger similar enhancements elsewhere with the commitments of the FAA, operators and OEMs to optimize the business for safety and efficiency.

Growing More Concentrated

MRO forecast underscores increasing domination of fewer aircraft types, importance of end-of-life services

Sean Broderick Washington

The commercial MRO industry is in consolidation mode, as providers respond to customers seeking fewer vendors by adding more services or snapping up complementary businesses. But the figures that underpin two recently released industry forecasts show that the airline aftermarket is marching toward consolidation in more fundamental ways as well. The equipment with the largest share of the MRO revenue pie is growing more dominant, while end-of-life services stand to become more important as the world's fleet undergoes a massive renewal, pushing retirements to record levels.

Aviation Week's latest Commercial Fleet and MRO forecast, released in late fall and covering the 10-year period through 2024, shows that 62% of current-year MRO demand of $56.3 billion is generated by 10 aircraft variants, with the Airbus A320 leading the way at $7.1 billon, just ahead of the Boeing 737NG. The rest of the top 10 will generate between $2.2 billion-3 billion in work this year. They are the 777-200, 747-400, 777-300ER, A319, 757, A300-300, A330-200 and A321.

In a decade, the MRO market is expected to be $85.2 billion, Aviation Week's figures show. The top 10 will hold about the same share of the market, but the 737NG will lead, at $12.0 billion, followed by the A320, at $9.4 billion and the 777-300ER, at $6.6 billion.

The rest of the top 10—the A321, 737MAX, A320neo, A330-300, A380, A330-200 and A319—will each account for $2.4 billion-4.4 billion. Eight of the top 10 MRO platforms will be in the top 10 aircraft as measured by fleet size as well (see chart). Two widebodies, the A380 and A330-200, will generate enough MRO demand to put them into 2024's top 10, ahead of larger ATR 72 and Embraer 190/195 fleets.

The most recent forecast by Cavok, formerly Team SAI, shows the landscape from a broader perspective. While Aviation Week's breakdown places common variants, like the A320ceo and A320neo, in different categories, Cavok's assumptions combine them.

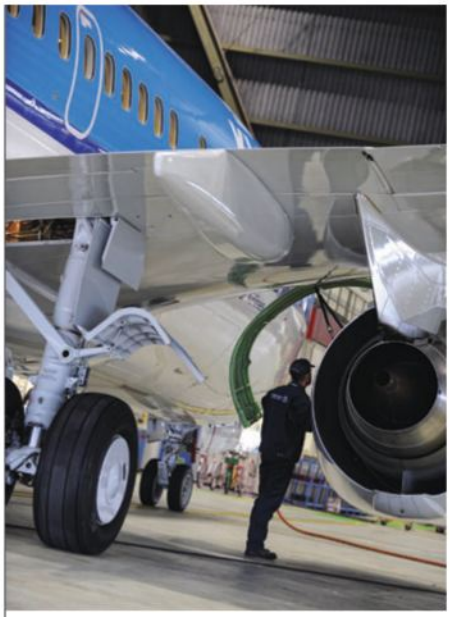
In Cavok's projections, 85% of the current-year MRO spend of $67 billion will be generated by what it categorizes as the top 10 aircraft types. By 2025, this figure will grow to 88%, led by the A320ceo/neo, 737NG/MAX, 777 and A330, which are Cavok's top four models today and are projected to remain atop 2025's list in the same order.

The A330 and 747 are the two other fleet types in the 2015 top 10 that will remain there in a decade, Cavok projects. New entrants on Cavok's 2025 top 10 list are the 787, A350, A380, Embraer's E-Jets, and the ATR family.

"Given the transition to newer generational aircraft . . . it is clear that MROs must be prepared to handle the type of activities associated with this changing mix, or focus their strategy to capture end-of-life markets," Cavok says.

As the decade progresses and new A320 and 737 variants come online, concentration at the very top will become even more pronounced. The A320's $16.2 billion in demand in 2015 will climb to $27.9 billion in 2025, while the newer 737s will see aftermarket spending go from $9.5 billion to $22.7 billion.

"To put this growth in perspective, the 2015 MRO spend of the 737 fleet is currently comparable to that of the third-largest fleet," the 777 "at $9 billion, "yet by 2025 the 737 MRO spend will be nearly double the 777 despite relative rankings remaining unchanged," Cavok notes. "In fact, by 2025, the A320 family and 737 series combined are forecast to constitute a greater share of the combined MRO market of all other fleet types."



AFI KLM E&M

Boeing 737NGs will make up nearly 15% of the global fleet and account for greatest MRO demand by 2025.

The 737NG and A320's combined 38% share of MRO spend in 2015 is expected to rise, to more than 50% in a decade. These figures follow Aviation Week's breakdown of each family by variant, in terms of fleet sizes (see chart). The combined A320 and 737 fleet is expected to account for 44% of the global air transport aircraft population by the end of 2015, Aviation Week's figures show. By 2024, this figure will rise to 52%.

"Newer, less diverse aircraft fleets will test providers' ability to compete," the Aviation Week forecast says.

The flip side of new deliveries helping reshape the world transport fleet is a record retirement level. Twenty years ago, an annual figure of 200 retirements was considered brisk. Now most forecasters expect retirements to hit the 1,000-per-year mark sometime in the next decade. Aviation Week sees this happening in 2021, and surpassing 1,200 in 2023. The forecast also indicates that 9,100 aircraft, including 1,198 freighters, will retire in the coming decade through 2024, nearly doubling the 4,700 aircraft retired in 2004-13. Deliveries by the end of 2024 will total 20,672, including 301 new freighters, leaving a fleet of 40,638 at the start of 2025.

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45% of the newly delivered aircraft for this decade will be 'replacement' aircraft. In the recent past, replacements only comprised approximately 20% of the market. Also of note is that the pace of parked aircraft has slowed, and returns-to-service from a parked status increased . . . signaling operators are utilizing their base asset capacity very efficiently."

Part of the new life for some older and parked aircraft can be explained by the drop in fuel prices. While operators are largely sticking to long-term fleet-planning assumptions that have oil at about $100 per barrel—a level Brent crude has not seen in more than six months—the low oil price environment is providing case-by-case opportunities.

Lessor AerCap earlier this year sold two A340s and one 747 that it had earmarked for teardown. But such assets are only flying for so long, cautions Executive Director Aengus Kelly.

"Airlines that we have those aircraft on lease with, with the current low-fuel environment, are taking those relatively fuel-inefficient aircraft and putting them into service for a few more years," he explains.

The in-service hard-stop continues to be driven by maintenance schedules, and to some extent passenger experience demands, rather than the end of the airframe's economic useful life.

"To overhaul four engines on a 747 or A340, plus overhaul the cabin—if you're going to upgrade it every few years, as airlines do with their new business product—between those two events you're looking at $30 million of capital spend," he says. "And no airline is going to do that, because they know [over time, fuel will rise]."

The growing pool of retiring aircraft creates opportunities for an expanding part of the industry: used serviceable material specialists. Their evolution is a microcosm of bigger-picture consolidation trends that are reshaping the MRO provider segment.

Companies like AJ Walter (AJW) and AeroTurbine have taken the competencies required to run successful parts sourcing and repair businesses, added the insight they have into their customers' needs, and built massive, multi-vertical service offerings that make them both more useful to existing customers and appealing to new ones.

AeroTurbine manages logistics for

Top In-Service Fleets by Aircraft Model 2015 vs. 2024

2024 Rank	Aircraft Model	2015*	% Total	2024*	% Total	Compound Annual Growth Rate (2015-24)
1	737-6/7/8/900	5,445	18.2%	5,880	14.5%	0.9%
2	A320	3,811	12.7%	3,835	9.4%	0.1%
3	737 MAX	0	0.0%	3,817	9.4%	NA
4	A320neo	12	0.0%	3,271	8.0%	86.5%
5	A321	1,190	4.0%	1,426	3.5%	2.0%
6	ATR72	740	2.5%	1,402	3.4%	7.4%
7	A319	1,352	4.5%	1,117	2.7%	-2.1%
8	777-300ER	614	2.1%	991	2.4%	5.5%
9	A321neo	0	0.0%	898	2.2%	NA
10	E190/195	703	2.4%	885	2.2%	2.6%
11	787-9	63	0.2%	875	2.2%	34.0%
12	787-8	324	1.1%	865	2.1%	11.5%
13	A350-900	60	0.2%	855	2.1%	34.3%
14	E170/175	526	1.8%	822	2.0%	5.1%
15	A330-300	616	2.1%	731	1.8%	1.9%
16	Q400	490	1.6%	656	1.6%	3.3%
17	A330-200	555	1.9%	631	1.6%	1.4%
18	CRJ700/900/1000	757	2.5%	612	1.5%	-2.3%
19	A330neo	0	0.0%	600	1.5%	NA
20	757	850	2.8%	478	1.2%	-6.2%

* projected fleet totals as of Dec. 31

Source: Aviation Week Commercial Fleet & MRO Forecast

737 and A320 In-Service Fleets by Variant 2015 vs. 2024

2024 Rank	Aircraft Model	2015*	% Total	2024*	% Total	Compound Annual Growth Rate (2015-24)
1	737-6/7/8/900	5,445	18.2%	5,880	14.5%	0.9%
2	A320	3,811	12.7%	3,835	9.4%	0.1%
3	737 MAX	0	0.0%	3,817	9.4%	NA
4	A320neo	12	0.0%	3,271	8.0%	86.5%
5	A321	1,190	4.0%	1,426	3.5%	2.0%
6	A319	1,352	4.5%	1,117	2.7%	-2.1%
7	A321neo	0	0.0%	898	2.2%	NA
8	737-3/4/500	1,090	3.6%	317	0.8%	-12.8%
9	737 BBJ	130	0.4%	202	0.5%	5.0%
10	737-800F	3	0.0%	118	0.3%	50.4%
11	A319neo	0	0.0%	102	0.3%	NA
12	737-200	125	0.4%	87	0.2%	-3.9%
13	A319CJ	70	0.2%	74	0.2%	0.6%
14	A318	49	0.2%	49	0.1%	0.0%
15	A318CJ	20	0.1%	21	0.1%	0.5%
16	A320CJ	10	0.0%	10	0.0%	0.0%
17	A321CJ	2	0.0%	5	0.0%	10.7%

* projected fleet totals as of Dec. 31

Source: Aviation Week Commercial Fleet & MRO Forecast

Moog's aftermarket support business, and last year launched a technical services division that helps operators and aircraft owners manage tasks like end-of-lease records transfers.

AJW recently won a multi-year deal to supply component maintenance, parts logistics, and consumables to EasyJet—part of the carrier's top-to-bottom re-tender of its maintenance services with an eye on lower costs.

"We considered a variety of service options from providers, looking at each part of the program separately, versus the multi-specialist approach provided by AJW," explains Warwick Brady, the carrier's CFO, citing the supplier's "best offer for the complete bundle of services" as a determining factor. Another major differentiator: the supplier's AJW Technique component repair and overhaul center in Montreal, which the company snapped up in 2012 as part of the divestiture of former Canadian MRO Aveos's assets.

As airlines push to streamline their operations, a vendor's versatility becomes a strategic advantage. AAR Corp. is best known on the civil side for its heavy maintenance services—it is the world's largest independent MRO provider—but its executives are most bullish on recent pushes into supply chain services, including consumables management for larger airlines and component support. AeroTurbine is part of AerCap, which has a fleet of 1,300 aircraft that it will continually turn over, providing a steady flow of equipment that AeroTurbine can use to support its customers—and potentially offering AerCap customers with a familiar source for disposing of older inventory.

Much of the consolidation and service expansion is around the engine and component businesses—no surprise considering their current shares of the MRO market and projected trajectories.

Cavok's forecast has engine MRO's share of the current market at 41%, or $27.9 billion. Among the four major MRO segments, it will grow at the fastest rate—a 5.3% CAGR clip that will see it reach $46.8 billion in 2025, when it will generate 47% of the global MRO spend.

Component work will climb from $12.4 billion to $19.2 billion in the decade, a 4.4% compound annual growth rate (CAGR) that will give it the second-largest share of MRO spend, 19%, in 2025. Widebody engine work has the lion's share, at 48% or $13.1 billion, with mainline narrowbody work at about 40%, or $11.2 billion. The balance is shared among regional jets and turboprops. The top spots will change by

LUFTHANSA GROUP

Narrowbody engine work is projected to surpass widebody work in the next decade.

2025, Cavok projects, with narrowbody engine work at 48%, or $22.4 billion, and widebody powerplants close behind at $21.1 billion, or 45%.

Climbing to third in total share over the next decade will be line maintenance, from $12.3 billion to $17.8 billion in 2025, or a 3.7% CAGR.

Falling from second to fourth in total share will be airframe MRO, moving from $14.5 billion today to $16.7 billion, or a 1.4% CAGR. The slow growth rate is directly tied to the evolution of composite airframes, which do not crack or corrode, and therefore will require less maintenance.

The good news is that established models with large sizes of mid-life fleets still flying—fewer than 10% of the 1,050 757s built are retired, for instance—which means ample opportunity for traditional airframe providers.

"From an airframe MRO perspective, providers must be able to address the demands of new composite and metal matrix airframe materials that are present in the newest generation of aircraft such as the 787 and A350," Cavok notes. "At the other end of the spectrum, the 757/767 fleet will still account for over 2% of the global MRO market in 2025, meaning those with proven 757/767 capabilities and competencies should be well-positioned to capitalize on the extended life of these aircraft."

The reduction in touch-labor requirements for composites combined with rising labor rates in developing markets will create opportunities for MRO providers in mature, higher-cost markets to keep work home. Aviation Week's forecast has North American operators generating 28% of the total share of airframe demand work in 2015, tops among world regions, and it will still hold 20% in 2024, behind Asia-Pacific. Lower labor costs in places such as China have helped Asia-Pacific grab a disproportionate share of airframe work—particularly widebodies—in the last decade or so, but signs indicate this is changing. Evidence includes new widebody MRO capacity built by U.S.-based providers such as Aviation Technical Services and AAR Corp., including the latter's greenfield facility in Rockford, Illinois.

Cavok calculates that North America generates $2.4 billion per year in airframe demand, and about 25% of it is shipped to other regions. "An examination of the flow of maintenance work among and between regions reveals that North America contracts more airframe maintenance to the rest of the world than it provides to other regions," Cavok notes. "Structural characteristics in the global economy such as labor rate differentials and complex supply chains have led to these trends; however, as the differentiators between developed and developing regions narrow, North America will be ripe to repatriate airframe maintenance currently contracted to other regions."

Adds Cavok Vice President Dave Marcontell: "We know from discussions with operators and MRO providers that there is substantial and extensive conversation to bring aircraft back."

Cavok forecasts the delivery of 18,068 new passenger aircraft and 423 new cargo aircraft through 2025, and the retirement of 7,346 passenger aircraft and 664 cargo aircraft over the same period. Under Cavok's assumptions, the current fleet of 23,927 aircraft will grow at a 3.7% CAGR to 34,408 aircraft, and 57% of deliveries will be for growth. Cavok's figures show that 33% of the current fleet will be retired in the next decade.

Gallery *See a brief history of aviation in Miami, site of our MRO Americas Conference and Exhibition, April 14-16:* **AviationWeek.com/MiamiAviation**

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Central American MRO Growth

Aeroman and Coopesa expand in size and capabilities; both are open to partnerships

Lee Ann Shay San Salvador, El Salvador, and San Jose, Costa Rica

Two Central American MROs have especially compelling stories. Aeroman launched service from a single-bay hangar with just a roof—and no walls; now it comprises 12 production lines in four hangars—with more on the way. Coopesa, the older of the two—it celebrated its 50th anniversary in 2013—has been working toward expansion for years and recently broke ground on a facility that should open in 2016.

In a region of seven countries and home to about 200 aircraft, these two MROs dominate—Aeroman in San Salvador, El Salvador, and Coopesa in San Jose, Costa Rica. While ST Aerospace took a stab at becoming a third player in the region, operating as Panama Aerospace Engineering, starting in 2007, that effort lasted only about six years because there was not enough demand in the region for three major players, according to the company.

Aeroman has grown exponentially since it started pursuing third-party work in 1998—despite some dramatic business challenges.

Originally an offshoot of TACA Airlines' technical department, Aeroman built its first hangar in 1994. TACA work filled just 75% of the capacity, so third-party clients were sought. Aerolineas Argentinas started sending Boeing 737-200s to El Salvador for the cost advantages, says Ernesto Ruiz, the MRO's chairman, who was then in charge of TACA and third-party MRO. "But in 2001, the economy of Argentina turned and became the cheapest country on the continent, so Aerolineas went home and we had capacity again," says Ruiz.

Then in 2001, TACA decided to switch from five models to one—the Airbus A320. This streamlining meant a reduction in maintenance requirements; instead of filling 75% of Aeroman's hangars, the figure was closer to 25%, according to Ruiz. At that time, the MRO operated four production lines and had to drop to three.

That prompted Aeroman to ramp up training on the A320 and pursue new customers—a move that proved pivotal.

"Attracting America West and JetBlue changed our lives," in 2004, says Ruiz, because they were U.S. airlines. And JetBlue, a newcomer on the low-cost carrier scene, was making a splash with LiveTV. "A satisfied customer is your best advertisement," he adds—and they really helped put El Salvador on the MRO map.

Aeroman became a founding member of Airbus MRO network a year later and by 2006 decided to build another hangar and aggressively pursue the third-party market. It found a minority investor and secured the holding company that owned ACTS, the spin-off of Air Canada's maintenance arm. ACTS, which later became Aveos, shut down in 2012, but its demise did not affect Aeroman's finances because the latter was a separate legal entity. That holding company withdrew from the MRO a year later, so a group of local and foreign investors took over in 2013, and "they believe in the company, as evidenced by our expansion," says Ruiz. Aeroman added its third hangar in 2008 and a fourth in 2012.

COOPESA

An aerial view of Coopesa's existing facilities at San Jose International Airport. It plans to move into its new facilities on the other side of the airport in 2016.

LEE ANN SHAY/AW&ST

Coopesa added narrowbody sidewall panel repair capability in late December 2014.

By 2014, Aeroman was at capacity and considered building a facility outside San Salvador. After carefully weighing the expansion/productivity balance, all signs pointed to growth. The company also explored taking on Embraer or widebody maintenance.

As these decisions were being pondered, a new government took over and made expansion and foreign investment easier. Aeroman signed a longer lease for its land—four years—at a more competitive cost than it had previously. "The growth in this country is slower than the rest of the Central American region," so the government is starting programs to attract investment, says Ruiz.

Today Aeroman operates 12 production lines and is scheduled to open its fifth hangar in late July. This 116,000 sq. meter (28.6-acre) hangar will be its biggest—capable of holding any aircraft (except for the A380)—up to eight narrowbodies or two A330s and three narrowbodies simultaneously. A second phase will include shops and a dedicated training building, and if workload dictates, there is space for a third, mirror-image hangar.

The fifth hangar introduces widebody work—A330s in particular. "Customers were asking for A330 MRO and there is not much capacity," says Ruiz, who also anticipates European operators flying to Mexico as potential customers. A330 training, which builds on the A320 experience, starts in May.

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If tooling—a critical component—arrives on time, Aeroman could be ready for its first A330 in September.

Bosco Rico, commercial director, says Aeroman also is looking at Boeing 767 and 777 maintenance.

Ruiz reveals that Aeroman and a potential partner are in discussions about developing composite repair services in San Salvador to enable in-depth structural repairs.

Aeroman's growth trajectory has been impressive—and sustainable. The company has been able to attract production lines—so it has steady, nose-to-tail work for major airlines. Although it lost JetBlue to Lufthansa Technik, which is scheduled to open a facility in Puerto Rico later this year, it still counts Southwest Airlines, American Airlines, Delta Air Lines and Avianca's Central American fleet as major customers.

The MRO's workforce is stellar, Rico says. "Walking around the floor, you see the energy and motivation, which is key to what we do." Southwest Airlines named Aeroman its top supplier during its most recent periodic review.

Aeroman recruits technicians from high school and pays for 1.5 years of external training. Afterward, the recruits receive at least two years of on-the-job training—with a salary and benefits. "We provide a career path here and don't just pay the minimum wage," says Ruiz. Turnover rates are only 2-3%, he notes.

Ruiz cites his employees' strong work ethic and notes that the MRO provides generous benefits, including services such as transportation to work, an on-site medical clinic, a daily cafeteria-provided meal and compensated time off for family matters.

Aeroman always has a pipeline of people in training, too—right now it stands at 200.

Given the competitive landscape—including aftermarket growth in Mexico (see page MRO18), Ruiz says Aeroman stays strong, and profitable, by delivering high-quality products on time—or ahead of time. It is also located in a free-trade zone, which means parts move in and out of the country easily and are not taxed. Aircraft land at El Salvador International Airport and taxi straight to Aeroman's hangars where staff immediately unload parts from the belly.

Coopesa, like Aeroman, is situated in a free-trade zone and also is building new hangars—but Coopesa will replace its functional (and full), but aging ones—so the whole company will have a fresh look. The more-than 50-year-old MRO has been planning for years to relocate—and admittedly, it has been "a bumpy process," says CEO Gabriel Gonzalez. But the good news is that ground was broken on March 17 and the facility is on schedule to open in 2016—14-16 months after construction starts.

The government needed Coopesa's land to expand the San Jose International Airport terminal—but because the MRO is a cooperative, the government is mandated to provide space at the airport equal to what it has now. While this is appreciated, it limits Coopesa's growth—so the MRO secured land adjacent to the new space for expansion.

The first hangar mirrors what it has now and will house six narrowbodies; the second hangar, which would double capacity and add workshops, could open as early as 2017.

LEE ANN SHAY/AW&ST

Aeroman has begun work on its fifth hangar, scheduled to open in July. It will be the MRO's first widebody facility and will be able to accommodate any widebody except the A380.

Coopesa's existing hangars are full, bustling with 55% of work from lessors and 45% from airlines on Boeing 737s and 757s, Airbus A319 and A320s, MD-80s and Embraer 190s. Given the high percentage of lease returns, maintenance scheduling can be tricky because these types of projects can hit snags and fall behind schedule.

"We're hoping for more nose-to-tail lines with the new hangars," says Gonzalez.

The facility already provides heavy checks, paint and post-delivery mods such as winglets for Copa Airlines, a strategic partner.

Other airline customers include Ecuadorian flag carrier Tame, VivaAerobus, Aeromexico, Gol, Bahamas Air, Cayman Airways, Avianca and Boliviana de Aviacion—along with most of the top leasing companies.

The MRO's upcoming facility transition has sparked palpable enthusiasm among employees and prompted capability expansion. Sidewall replacement services were introduced in late 2014, and the MRO would like to offer component maintenance, such as brakes, wheels and landing gear. "Our intention is to look for joint ventures," or other strategic alliances such as the ones it established with Pemco for 737 cargo conversions or the Canadian training company FlightPath in January.

Coopesa completed four 737 conversions for Pemco last year and anticipates the same number in 2015.

In the meantime, it gained Airbus approval in December 2014 and hopes to become part of the Embraer maintenance network in June. In the first quarter, Coopesa employees were enrolled in structural engineering classes in Toulouse, logistics training in Miami and material planning in Ashburn, Virginia, all related to Airbus work.

The Costa Rican MRO employs 702, of whom 480 are associates, or cooperative owners. The rest of the staff are in the process of becoming associates.

Like Aeroman, Coopesa says it has very low turnover, but it faces a shortage of mechanics because of growth projections.

To solve this, it initiated an alliance with a local training school, whose graduates can come to Coopesa for additional, financed training before applying for their license. In 2014 this yielded 32 graduates with a local license and six with an FAA-issued license.

Coopesa is totally booked through the end of May and is 70% booked for the second half of the year. The only remaining slots are available during the airlines' peak summer and December flying seasons.

It performs 90% of line maintenance at San Jose International.

Given the growth at both Aeroman and Coopesa, it would be difficult for another MRO to gain a foothold in Central America.

Galleries *See Aeroman's and Coopesa's expanding MRO operations:* **AviationWeek.com/AeromanCoopesa**

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Mexican MRO Capacity

Projected Mexican airline growth drives expansion

DELTA TECH OPS PHOTOS

Henry Canaday Washington

TechOps Mexico's shop in Queretaro operates nine lines of maintenance.

In contrast with many mature regions, Mexico may soon need a few more good hangars. Traffic growth is healthy, and the country will get about 150 more Airbus A320-family jets in the next few years. Longer term, Boeing expects to deliver around 400 aircraft to the country in the next two decades.

There is significant capacity at MRO providers like Aeromexico and the newly independent Mexicana shop, and more might be added there. An independent MRO, QET Tech Aerospace, might expand with fresh funds. One attractive solution would be a sophisticated global MRO partnering with a Mexican company, but it is not yet clear that will happen.

None of this is urgent. Mexico has capacity for its immediate needs, and can always go south for extra room. But more hangars in Mexico would probably be more efficient and might attract work from some of its neighbors.

VivaAerobus is a Mexican low-cost carrier (LCC) transitioning out of its 737 fleet and moving into A320-family aircraft. The carrier has ordered 52 new A320s and A320neos for delivery from 2015 to 2021.

As an LCC, VivaAerobus seeks to outsource its major maintenance. CEO Juan Carlos Zuazua sees maintenance capacity in Mexico as limited, but expects it to grow with some new projects coming in. "Some airlines have integrated vertically, established their own MROs and now offer it to third parties, for instance Aeromexico and Interjet," Zuazua observes. "And there are some private companies interested in developing MROs in Mexico."

VivaAerobus has not had a heavy check due on its A320s yet, but the CEO believes there will be capacity available. He points to Mexicana MRO, which is no longer involved in its parent's bankruptcy and which has "great capabilities for heavy maintenance."

For the long term, Zuazua says Mexicana MRO is only one of several options. "We also work with Coopesa in Costa Rica and Pulsar in California. And there is an interesting project in Chihuahua coming for 2016 with local businessmen and ST Aero, which looks very promising."

The airline has made no commitments yet. "We will evaluate all shops, their qualifications and most important, their cost." More generally, he is optimistic that growing Mexican aviation will find the support it requires. "I see no problem with the combination of airline MROs and third-party MROs."

Mexicana MRO is currently run by a commission for the benefit of its employees, explains Director General Marcos Rosales Gomez. Once part of a major airline, the MRO has been certified by FAA, EASA and aviation authorities in Argentina, Brazil, Chile, Ecuador and Peru, as well as Mexico. The company added El Salvador and Aruba to its certifications last year.

The MRO provider supports A320s and A330s, 737s and 767s and Fokker 100s at present. Its 200,000 square meters (2.1 million sq. ft.) of space in Mexico City are still a very substantial operation, although Mexicana's 1,100 employees are down from the 1,500 18 months ago, before the MRO was spun off from the bankrupt parent airline.

Mexicana worked on 180 aircraft in 2014 and plans to grow volume by 10-15% in 2015. It will continue to focus on narrowbodies, but wants to work on more widebodies like the 777 and 787 in three to five years.

Gomez says Mexico's shops have enough capacity now, but with traffic growing 3-6% annually, the country will soon need more. And he expects the opening of a new airport in Mexico City to increase traffic substantially. The first phase of the new airport is scheduled to open in 2020.

Mexicana MRO will move to the new airport when it opens. It has some unused space in Guadalajara, but plans to concentrate all its activities in Mexico City.

"We have been through difficult times," Gomez acknowledges. But Mexicana MRO is leaner and disentangled now, and optimistic about its future.

Aeromexico's joint venture with Delta TechOps, TechOps Mexico, is another significant resource. President Miguel Uribe says his new facility is state-of-art and eco-friendly, with solar cells, rainwater harvesting, wastewater recycling and LED lightning.

TechOps Mexico has three hangars with capacity for nine aircraft, and Uribe says it has the space and technical expertise to double capacity to 18 lines. Even with current capacity, up to two lines can be offered to third parties.

TechOps Mexico works on Embraer 145s and 190s, 737NGs, MD-88s and -90s. Uribe says it will expand in the future according to market opportunities.

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Obregon in the northwestern state of Sonora. Mike Dornenburg, vice president-technical and commercial operations, says the MRO employs 54 people in all. He expects QET to double its staff this year to accommodate contracts for line maintenance and lease returns.

QET uses one-off approvals to complete heavy checks on Boeing, Airbus and Embraer aircraft. The MRO has passed an audit for an FAA certificate and expects to soon receive FAA approval for a battery shop, A320 line maintenance and CRJ200 heavy maintenance. "We will be working on expanding these capabilities quickly," he says.

The company has a hangar with capacity for four narrowbody or six regional jets, but can accommodate more for a short time. In January it housed two 737s in the hangar set for recycling in February, and keeps half of the hangar available for heavy maintenance.

The MRO provider has a two-phase plan for expanding hangar capacity in collaboration with the state of Sonora. It is also looking at empty widebody hangars in Guadalajara and Tijuana. But QET would need an investor to be able to expand its facilities and capabilities to other models, such as ERJs, A320s and 737s.

An immediate shortage of technicians is not one of the challenges facing aviation in Mexico, according to Dornenburg. "There is presently an overcapacity of skilled aviation mechanics available because of the Aeronautics University Of Queretaro (UNAQ) and the difficult times at Mexicana."

Line service also appears quite adequate. Aviation Integrated Services Group (AISG) performs line maintenance and maintenance training, according to President Bogart Balmori. The company provides line services for 64 airlines at 22 Mexican airports, giving it the largest customer count among Mexican line-MRO providers.

At its base in Cancun and also in Mexico City, AISG trains mechanics to work on A320s and 737s and will soon expand to Embraer 190s. Students are given courses in safety, human factors, electrical wiring interconnection systems (EWIS) and evaluating structural damage. AISG trains about 150 techs a year for both its own staff and others. It is certified by the Mexican DGAC, EASA, FAA and a number of international aviation authorities.

"We have no plans to do heavy maintenance," Balmori says. "That would be a different ball game." He does plan to increase his staff of 145 employees proportionate to aviation's growth in Mexico.

There are several significant providers of line maintenance in Mexico, and Balmori believes this sector is well-covered. However, "Mexico definitely needs more heavy maintenance. Mexican carriers have to send aircraft outside Mexico."

Balmori says the only airline thoroughly prepared for growth is Aeromexico, with shops operated for itself and Delta Air Lines. "They have huge infrastructure, but also huge fleets and are mostly dedicated to Aeromexico and Delta fleets."

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The AISG chief expects VivaAerobus, Volaris and Interjet to have about 150 A320-family aircraft in a few years and does not see sufficient capacity to support them. He doubts Mexicana MRO can do the job, at least in its present condition. "I don't think it has the financial resources to endure or develop for the future unless a major company purchases them. They are behind in standards and technology. If a major company purchases them, then they can be successful." He hopes Mexicana, if purchased, stays independent rather than working for just a single airline.

Balmori has heard a rumor that Lufthansa Technik might come into Mexico, but LHT has now committed to Puerto Rico. If another MRO does start up, location might be important. Balmori says an MRO that wants to serve chiefly the Mexican market should be centrally located. For example, Guanajuato is well-situated for serving Mexican carriers.

If an MRO also wants to support the U.S., Caribbean, Central and northern South America, Balmori recommends locating on the Yucatan peninsula, for instance, at Cancun. "It's connected to everywhere," he argues. Indeed, Cancun now leads Mexico in the number of operations and international flights.

Queretaro might be another option. Messier-Bugatti-Dowty has a landing gear shop there that overhauls 40% of the A320 landing gear and 10% of the 737 landing gear in the Americas. MBD Senior Vice President-Sales and Business Development Alan Doherty expects the 737 share to increase.

Doherty says Queretaro has been an extremely good location for doing overhaul business in Mexico. "It's an extremely modern city with good services. There is a big university [UNAQ] with a good graduate program. Bombardier also has a shop there."

Located at Queretaro International Airport, UNAQ offers extensive courses in both aircraft manufacturing and maintenance. There are programs in avionics maintenance, aircraft maintenance and engine maintenance and precision manufacturing available to the university's 3,000 students.

Bombardier began manufacturing in Queretaro nearly 10 years ago. More than 1,800 employees make harnesses and electrical subassemblies for business and commercial aircraft, and airframe structures and flight controls for Q400s and CRJ700s, 900s and 1000s.

In the northern state of Chihuahua, major aerospace OEMs make a variety of structures for fuselages, wings and cabins. Local facilities also fabricate seats and emergency systems.

Fokker creates empennages in Chihuahua and Honeywell makes turbine components. Nordam manufactures thrust-reverser components, while Safran makes electrical systems there.

Chihuahua's main advantage is its northern location and very good road connections to the United States, which may make it more attractive for manufacturing aircraft components than for overhauling them.

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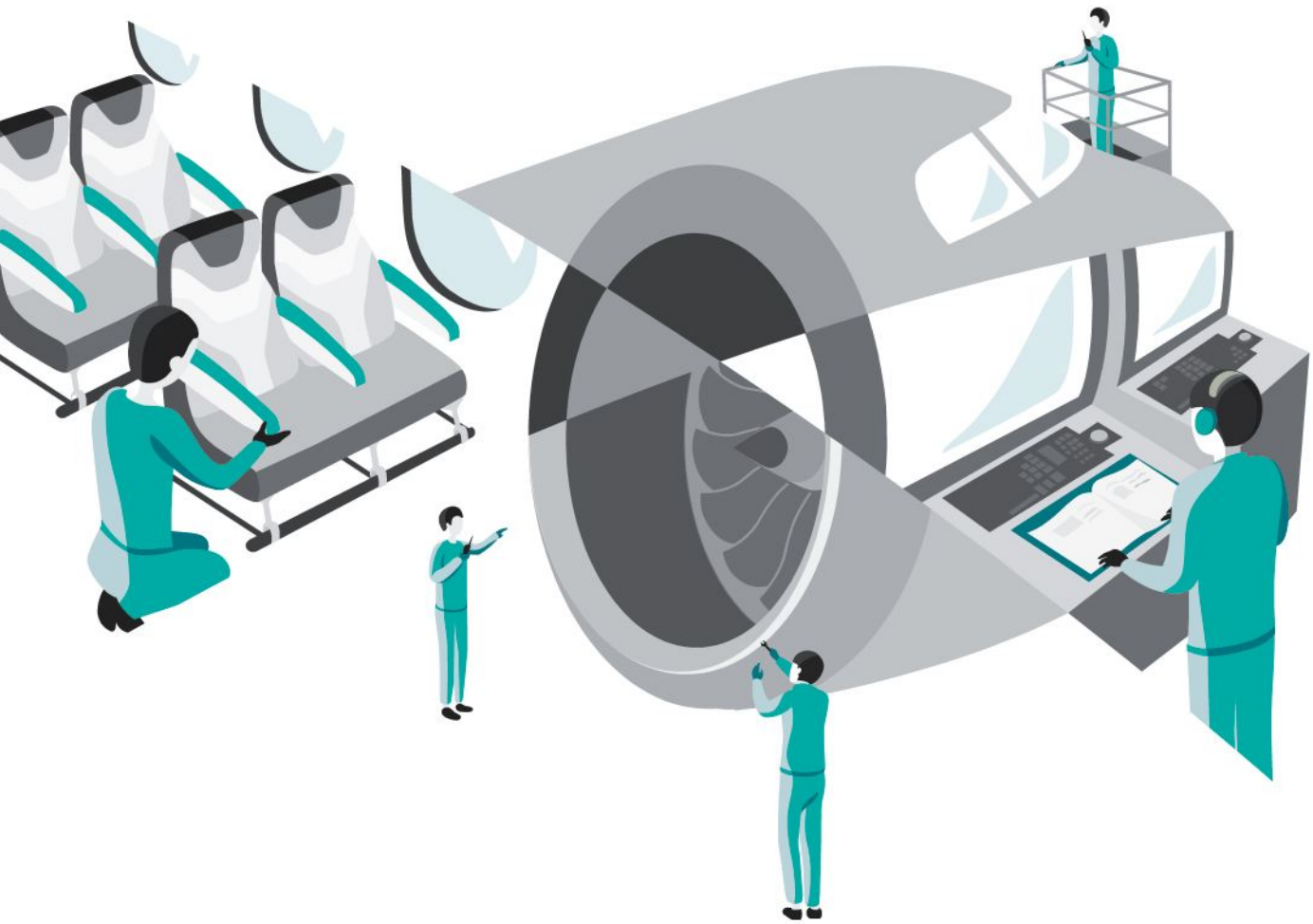

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Will Low Fuel Prices Ramp Up MRO?

While the answer may be 'a little,' there are pockets of opportunity

Paul Seidenman and David J. Spanovich San Francisco

Airlines are reaping windfall profits, largely due to drastic fuel-cost reductions. To illustrate, according to U.S. Energy Information Administration statistics released on Feb. 25, West Texas Intermediate (WTI) crude was selling for $49.56 per barrel, while Brent crude was priced in Europe at $59.78. About the same time last year, the respective prices were $102.88 and $108.98. That has translated into bargain prices for jet fuel, priced as of Feb. 25 at $1.84 per gallon for U.S. Gulf Coast Delivery, a 61% reduction compared to $2.99 at about the same time in 2014.

The jury is still out as to whether lower fuel prices will become the new normal, and thus, if legacy fleets of less fuel-efficient aircraft will remain in service longer, giving the MRO industry an unexpected dividend. The answer depends on whom you ask. For now, the signals are mixed.

"Given today's lower fuel costs, some airlines are looking at keeping some of their legacy aircraft in service longer. I expect that during 2015, some benefit will start to accrue to the aftermarket support industry as a result," says Ken Herbert, managing director, aerospace and defense research in the San Francisco office of investment banking firm Canaccord Genuity. The money that airlines save on fuel, he says, will translate into more maintenance spending, which means less deferred maintenance, and more discretionary spending—such as interior upgrades—which he expects to accelerate in 2015.

This, Herbert reports, will create a more favorable pricing environment for MRO providers, through long-term contracts and ad hoc work. "If your customer is going to make more, then the service provider will see that as the time to get a price increase—which will be a lot easier to push through."

A more conservative view is held by Brian Foley, president of Brian Foley Associates, an aviation market research firm in Sparta, New Jersey. "Although I am bullish on my outlook for the MROs, the low fuel prices are not going to mean double-digit growth for the industry this year," he states. "What I do see is a gradual ramp-up over time."

In that regard, Foley discerns a trend among MROs to extend contracts on older aircraft, and make those contracts more favorable in order to retain clients as well as attract increased business. "The MROs are in the thinking and hopeful stage, that low fuel prices will continue. That will bring in the older, more maintenance-intensive aircraft, especially as orders for new aircraft are deferred," he explains.

Robert Gaag, sales director-USA and Canada for Lufthansa Technik, predicts "limited opportunities" for MROs in the field of engine and airframe maintenance, and possibly cabin modifications on aircraft that are likely to continue flying because of the changing fuel economics. However, he points out, new equipment on order with the OEMs will continue to replace older models.

"These new aircraft will be delivered to the airlines whatever the fuel price will be, so any deferred retirement of older aircraft might be used by some airlines to cover certain routes for a season or two, but not necessarily long term," he remarks. "The effect on additional MRO needs will be limited, but it will influence the availability of cheap spare parts from dismantling of those aircraft."

STANDARDAERO PHOTOS

StandardAero of Winnipeg sees a continued need for legacy regional jets, as some come out of storage and return to service for at least another 1-4 years now that low fuel costs are making them more economical to fly. The company is a major supplier of MRO services on the CF34 engine, which powers some of those aircraft, and believes that engine maintenance will lead to an incremental increase in their business as those models continue to operate.

James Halstead, managing partner at Aviation Strategy, a London-based consulting firm, reports that some resurgence in demand for legacy four-engine aircraft may be in the offing. "When oil was in excess of $100 per barrel, anything with four engines was painful to operate, and consequently, retirements and disposals of the Boeing 747-400 and Airbus A340 accelerated," he notes. "Now, with oil going at around $50 per barrel, the four-engine transport is a little more attractive."

Halstead cites the A340 as a prime example, which he says

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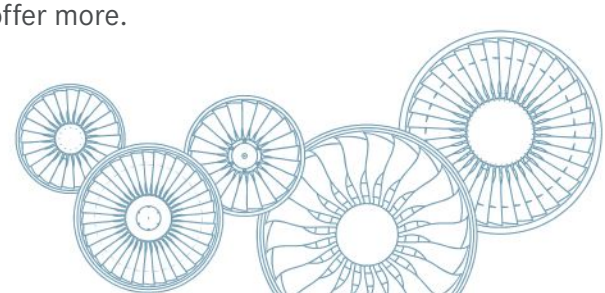


the leasing firms appear to be pushing back into the market, based on current fuel pricing, lower lease rates and the capital investment required to put them into service. "Compared to the 747-400, the lower capacity of the A340 gives it more flexibility in markets and on routes where it could be deployed," he says.

Nonetheless, Halstead stresses that there is still the issue of the operational life of an aircraft, which could be determined by how much longer fuel will be bargain-priced. "There may be a difference in thinking about the life of the aircraft, but then the question becomes, 'are we looking at a sustained low-fuel-cost environment, or a temporary one?' That will have a lot to do with life-extension decisions of older aircraft."

Airlines that are not currently evaluating their fleet planning under the current economics—soon will be, according to Brian Foley. "With respect to continued operation of older aircraft, many airlines are taking a wait-and-see attitude to determine whether the lower fuel prices will remain in effect for a while. The fact is, some airlines have not looked at this yet in terms of their own strategic fleet planning."

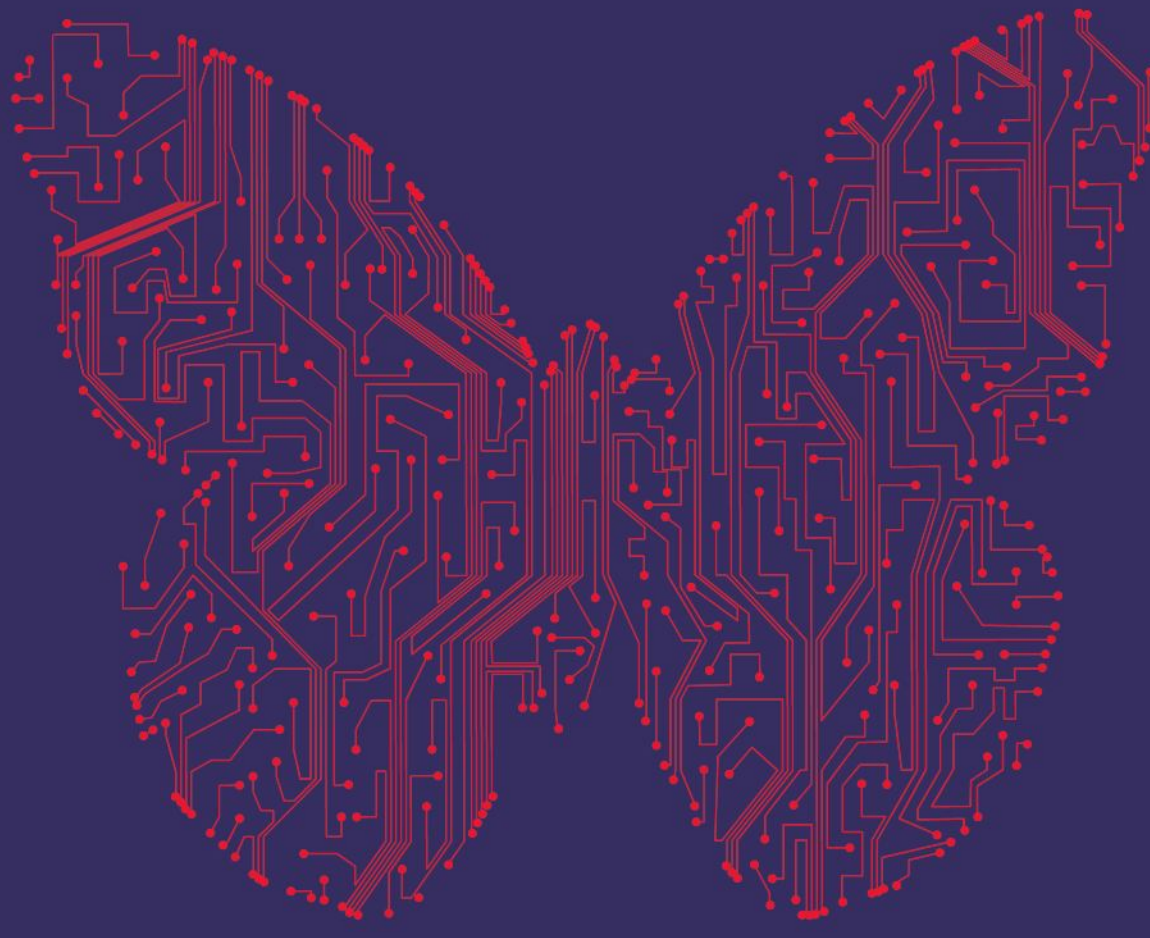
The "wait and see" view may be advisable, according to Richard Brown, London-based principal at ICF International. "While oil prices have fallen recently, they remain at levels much higher than we saw five years ago," he says. "ICF and others suggest that fuel prices at current levels represent a short-term fluctuation, driven less by market fundamentals than by political motives, as OPEC seeks to maintain market share and U.S. shale drillers increase supply."

Brown also argues that a much longer run of sustained low fuel prices will have to occur before there will be any impact on aircraft retirements. "Most airlines plan for fuel prices to remain high, and therefore their best options to protect themselves against fuel price volatility is to invest in a modern fuel-efficient fleet."

For now, it appears that the wait-and-see approach is prevailing. "We have not seen any increased demand for legacy engine MRO services due to lower fuel prices, or additional utilization and retirement delays of older aircraft," says Scott Brensike, general manager-mature fleet solutions, at GE Aviation. Still, he concedes that market trends could change if low fuel prices are sustained for at least the next 12 months. At the same, fuel-hedging issues come into play.

"Fuel prices have been low just since October 2014, which is still within the average period when current airline fuel-hedging contracts have been in effect," Brensike says. "Since many airlines have hedging contracts in place, that has deferred their ability to benefit from any savings on fuel. There is a lot of variability with fuel-hedging strategies that will determine when that will happen."

If low fuel prices should continue for the long term, says Brensike, it is possible airlines will decide "to go into greater depths of overhauls and shop visits." In that regard, he cites the CFM56-3, the CF34-3, and the CF6 as the most likely GE powerplants to generate demand for MRO services due to continued operation of older aircraft. For the CF6, however, the uptick in the air cargo market may be what will drive maintenance events for the near term. "We have seen what seems to be strong growth in



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air cargo services over the past 18 months. That segment of the CF6 market, in fact, has shown some positive underlying trends."

Not everyone is betting on low fuel prices to be of long-enough duration to affect fleet and maintenance planning.

"The lower fuel prices have had little impact on our plans, as we don't expect oil prices to remain at these [current] levels for a significant amount of time; or at least long enough to substantiate longer-term decisions and investments such as fleet acquisition and modification strategies, which can span years," says Trevor Stedke, vice president-technical services at Southwest Airlines.

For example, Southwest has been active over the past 24 months—well before the downturn in fuel prices—in the used 737-700 market, through both purchase and leasing arrangements. According to Jon Stephens, the carrier's director of fleet transactions, the main reason has been augmentation of the airline's orders for new aircraft from Boeing. Specifically, Southwest added 22 737-700s in 2014, with commitments for another 16 this year, and four in 2016.

While low fuel prices can't hurt, there are those who caution not to expect them to generate a MRO market bonanza. Statistics compiled by ICF International predict a $64.7 billion global MRO market for this year, up slightly from the $62.1 billion in 2014. "Sustained fuel prices would have to be present for longer than a year before airlines start making changes to their fleet plans," says ICF's Richard Brown. "Most energy experts expect fuel prices to increase rather than stay low."

Troy Jonas, vice president, global sales and marketing-aircraft engineering services, for AAR Corp in Indianapolis, thinks that even if fuel prices remain low, "we do not believe they will substantially move the dial for MRO services, beyond where it already is," he says. "However, we continue to anticipate an expanding MRO market."

On the other hand, Jonas reports that AAR is witnessing at least some operators recommissioning older aircraft. "At least a handful of 757s have come out of storage within the past 12 months, now that they have become more economical to operate." He adds that older wide-bodied aircraft, particularly the A340, 736 and A330, as well as some 777-200s are also generating activity at AAR.

Lower fuel costs also may be breathing new life into the 50-seat CRJ 200, which many industry observers believed would go away under sustained high fuel-pricing.

"From a strategy standpoint, we see a continued need for those aircraft," says Todd Sywake, vice president-business development and customer programs for StandardAero in Winnipeg, Canada. "Lower fuel costs are making them more economically viable, and some are coming back into service with the regional airlines, providing at least a short-term capacity solution." StandardAero maintains the GE CF34 powerplants, as well as the Honeywell 36-150 APUs on the aircraft.

Sywake adds that StandardAero is in discussions with operators in North America and Europe to provide MRO services, as some of the legacy regional jets come out of storage. "We can see at least an incremental increase in our MRO business, as those airplanes fly for another one to two, even three to four years," he says.

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WHAT IT TAKES TO FLY.

Smart Flight-Hour Negotiations

Before signing a long-term component support contract, make sure you know certain details

Henry Canaday Washington

Finding the best deal on component maintenance has in one sense become much easier. OEMs, MROs and asset managers now offer support programs, by part number or nose-to-tail, including all or some of the necessary services, for fixed charges, mostly per flight hour. But how does an airline choose between in-house or outsourced support, and how much does it outsource?

Smart component policy requires an ability to evaluate and choose among these deals, weighing them against in-house options and picking just the right parts and tasks to send out. Perversely, the largest airlines that need flight-hour programs least usually judge them very cleverly. But smaller carriers that need this kind of support most intensely are not always wise in choosing a provider or agreeing to specific terms.

So it is worth going over the basics. The first question is, Which components are the best candidates for flight-hour support? "The ones that come off most frequently, avionics, mechanics, hydraulics, pneumatics," summarizes Cavok Vice President David Marcontell.

Deepak Sharma, chief technical officer of AJW Group, agrees. Flight-hour support works best for components that are removed at high or moderate frequencies. He recommends this approach for components with a mean time between removal (MTBR) at or less than 100,000 flight hours, or about four years.

Richard Brown, a principal with ICF International, says airlines typically keep high-value components outside flight-hour contracts since these repairs can be negotiated separately to get the best price, often from component OEMs. These high-value components include wheels and brakes, APUs, thrust reversers and some avionics.

The in-house versus outsourcing choice also depends on size of fleet, existing maintenance infrastructure, labor cost and productivity, availability of viable outsourcers, part complexity and airline financial strength. Maintenance spending can also be important. "Some airlines perform wheel and brake maintenance in-house because of the large spend and frequency of replacement," Brown observes.

But the trend is clearly toward outsourcing, partly due to difficulties in obtaining test rigs for the latest equipment and repair data and partly due to limited airline finances. And the best candidates are high-frequency parts, for which in-house infrastructure does not exist.

AJW GROUP

It's worth probing the entire supply chain and how it is managed when considering flight-hour support agreements.

Next, an airline must do its homework thoroughly. Marcontell stresses that an airline should know the costs of keeping work inside even if it expects to receive three or five highly competitive bids, because carriers always have the choice of how much to outsource, whether to manage time-and-material repairs in-house, manage assets or outsource that function. And they can choose which parts are covered in a flight-hour agreement. By estimating the costs of all in-house options in detail, carriers can make smart and specific choices, not just all-or-nothing choices among proposals.

That means estimating by part numbers. Start with mean time between removals, and don't rely just on suppliers for MTBR. Airline reliability data should be used, and peer-carrier data should also be used if available.

Distance to shops and turnaround time are also important. If an airline manages time and material repairs itself, it needs these figures to calculate the true cost of repairs and the time required, which will affect inventory costs. The airline also needs to estimate repair costs, which Marcontell says can be obtained from the market sources.

"Now you know how often, how long and how much," Marcontell notes. This gives an estimate of repair costs per flight hour, which can be compared with proposed rates from suppliers.

If outsourcing asset management is being considered, the airline must next estimate the cost of holding spare inventory, again by part number. In-house inventories are figured by required spare provisioning list (RSPL) models using Poisson distributions. Here the carrier must choose the service level(s) it needs and whether it is willing to share inventories with other airlines. Once the RSPL estimates the inventories required, operating costs will include financing and warehousing and usually run about 1.1% of inventory value per month.

Combined with the airline's operating plan, the steps above should yield the cost per flight hour of repairs and asset management, by part number. These are the basic benchmarks for judging flight-hour proposals.

AJW's Sharma agrees with Marcontell on the importance of these steps. "Know your demand patterns, cost bases, repair costs, pool costs and the costs of maintaining the pool."

Sharma says OEMs and suppliers should be only one source of cost and reliability data, for MTBRs can vary by region. For example, in the Middle East and other hot regions ATA Chapter 21 air-conditioning units are removed more frequently. And Sharma notes that internal airline practices will also influence support costs. One obvious example is the service level expected, which will strongly affect inventories required. Another possible variable is testing. One U.S. cargo carrier requires each component be tested in ways that go beyond OEM recommendations, which adds to costs, whether done inside or externally.

With internal flight-hour costs estimated in detail and robustly, the RFPs can go out to responsible providers. Then it's time to get down to business. Most carriers use a weighted-metric system to grade proposals. The most common metrics are price per flight hour, risk and turnaround time.

Marcontell urges airlines to also seek a reliability commitment from the provider. Even though the supplier is covering all repair and inventory costs in the flight-hour charge, each removal costs the airline money.

What else should the airline ask for in the RFP and look for in proposals? Plenty, according to Marcontell.

First, airline staff need to think about no fault found (NFF) and rogue parts. NFFs can be caused by bad airline troubleshooting or bad repairs by a supplier. In either case, NFFs cost money just for removals and may cause a disruption in service. One way to handle NFFs is to set a threshold, says 10-15%. If NFFs are less than that, the provider bears all costs. The airline would bear NFF costs above the threshold.

Rogue parts are the individual serial numbers that keep showing up as NFF. Both airline and MRO need to get rid of these parts fast, and any flight-hour contract should specify in detail solid methods for shedding these expensive miscreants.

Marcontell also encourages airlines to ensure that they have control over any third-party shops that are used to perform repairs. And asset managers may want to supply upgraded parts in place of older ones. "Make sure you can confirm changes, as they may not suit all your fleet."

Another criterion for judging proposals is how easy it will be to shift parts to another location when and if the airline changes its operations. Will the contract have to be entirely renegotiated at an expensive premium? Or does it provide reasonable flexibility at reasonable cost?

The quality of a provider's customer service should also be taken into account, if only by contacting references. Problems do arise, even with the best companies.

Furthermore, Marcontell says, many airlines do not sufficiently consider their exit strategy from a flight-hour agreement. "What if your operations or business model change, or the supplier's performance deteriorates due to a change in ownership?"

Finally, if the supplier is an OEM and the agreement is for 10 or 15 years, "make sure they will exploit used serviceable parts in the out years," Marcontell advises. OEMs may prefer selling new parts when used parts could be obtained at 40% of new costs.

Other experts have some more general advice. "Performing MRO is just one part of the offering," cautions ICF's Brown. He says reliable suppliers will also need excellent planning software and solid logistics. "Lufthansa Technik has an in-house logistics division, while other suppliers partner with logistics providers such as DHL, UPS or Cat Logistics." It's worth examining the entire supply chain and how it is managed.

Brown notes that OEM pricing can be higher for flight-hour agreements. OEM expertise may be worth a higher price, but where does it show up in the contract? In promised reliability improvements? In financial strength to honor all commitments?

If airlines are looking for a single, broad offering, they will often prefer full-service MROs or asset managers. This may be the best deal, but carriers should consider all their alternatives.

Sharma says too many airlines judge proposals just on price and do not consider how a supplier could tailor a solution to provide more value. Additional benefits that the best asset managers might provide are IT infrastructure, logistics and different service levels for different maintenance bases. "Say they require a part within 12 hours of a call," he explains. "But we propose that we will average within six hours of a call. They need to be able to evaluate that."

Some airlines want their parts at list prices, because they only understand list prices. Sharma says carriers could save money by using market value, which is simple for asset managers to calculate with three to five phone calls for quotes. "They end up paying more for list prices."

Exploring these kinds of questions requires face-to-face meetings between the airline and proposing supplier(s).

AJW GROUP

An AJW Group executive suggests flight-hour support works best for components with a mean time between removal of below 100,000 flight hours, or about four years.

Sharma recommends airlines start out by reviewing up to 20 paper proposals, then down-select to about seven or "as many as will come in for face-to-face."

So negotiating a least-cost, high-quality flight-hour agreement takes time and attention to detail. But the airline will be living under the agreement for a long time. It's worth the work to get it right from the start.

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787s in Copenhagen

Monarch's maintenance arm to run Boeing's new leased hangar for GoldCare in Copenhagen

Tom Pleasant London

Boeing has launched a new GoldCare MRO facility at Copenhagen International Airport. The airport's second-largest hangar has been leased to house the operation. Monarch Aircraft Engineering Ltd. (MAEL) has been awarded a two-year contract to run the facility.

MAEL, the independent aircraft maintenance division of the U.K.'s Monarch group, will station 20 engineers at the airport to provide comprehensive phased checks, service bulletins and defect rectification.

"[MAEL] has a long history of successful, high-quality maintenance and is a great fit to provide the maintenance component for our 787 GoldCare," said Bob Avery, vice president-fleet management for commercial aviation services, Boeing Commercial Airplanes.

Monarch Airlines had ordered six 787s in 2006 for deliveries starting in 2010, but delays to the type pushed actual delivery to 2013 and led the airline to cancel its order in 2011. MAEL, having already started training on the type turned instead to servicing 787s as a third-party provider in 2010.

Notably, Boeing contracted it in February 2014 to head MRO ops for Norwegian Air's 787. This was following the Scandinavian low-cost carrier's highly critical complaints about the aircraft type's early reliability.

MAEL Managing Director Ian Bartholomew says, "Our strategy is to continue our partnership with Boeing GoldCare, enhance our 787 experience on the lighter and the heavier phased checks, and to cement MAEL as a leading 787 MRO [provider].

"This is the latest step in our journey as a GoldCare partner," he adds, "one which we started in 2010, and have rolled out across all of our four U.K. maintenance bases. Now," he says, "we're extending our work to customers at an overseas base."

Norwegian and Qatar Airways both operate the 787 to and from Copenhagen airport, and will presumably be the first customers for MAEL's services.

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Impossible Fixes

SSJ100's lack of FAA approval is proving troublesome for some U.S. suppliers' MRO support

Sean Broderick Arlington, Virginia

U.S. and European regulators are working to solve a regulatory challenge that is preventing some major U.S.-based Sukhoi Superjet 100 (SSJ100) program suppliers from performing routine maintenance on their products.

The aircraft has been certified by several civil aviation authorities, including Russia's IAC and, notably, the European Aviation Safety Agency (EASA). But despite early plans to seek FAA certification, the SSJ100—which does not have a U.S. operator lined up—does not have U.S. approval.

Under the safety bilateral between the U.S. and European Union (EU), EASA can certify U.S.-based repair stations, but work performed by those shops must meet both EASA and FAA regulations—a practice known as a "dual release." However, because the SSJ100 is not FAA-certified, U.S. repair stations cannot legally repair parts for the aircraft since they cannot be restored to the agency's definition of airworthy—a fundamental requirement in the agency's maintenance regulations.

An exception is if the parts have stand-alone FAA approval, as opposed the blanket approval obtained via the entire aircraft's certification. While some U.S. suppliers such as Honeywell obtained such approval for their SSJ100 parts, others did not. As a result, providers are scrambling to figure out how to repair parts that SSJ operators are sending in, and in at least one case, the supplier has resorted to the expensive alternative of providing new parts instead of less-costly repairs.

Regulators last month told a gathering of MRO executives that they are aware of the problem, but cautioned that solving it may not be easy. "That's something we are looking at internally," FAA International Policy Office Manager Chris Carter told attendees at the Aeronautical Repair Station Association (ARSA) annual meeting.

Carter pointed to airliner development programs in China and Japan that may present similar challenges if major civil aviation authorities do not certify them. "I don't have an answer for you today, but it is something that's on our radar," he said.

The SSJ100's U.S. content includes B/E Aerospace cabin furnishings, Hamilton Sundstrand electrical systems, Honeywell auxiliary power units (APU), Parker Aerospace hydraulics, and UTC Aerospace Systems wheels and brakes as well as brake control assemblies, which include parts from other U.S. suppliers.

SUKHOI

A few U.S.-based suppliers face regulatory hurdles supporting SSJ100 operators.

Honeywell confirmed that it can repair APUs in the U.S. and at a facility in Germany. Several other suppliers declined to speak for attribution or did not respond to requests for comment, but Hamilton Sundstrand and UTC Aerospace Systems are said to be among the suppliers facing the problem.

One supplier source confirmed that Sukhoi currently has no plans to pursue FAA certification for the SSJ100. Sukhoi did not respond to inquiries.

At a minimum, the issue is causing logistical headaches for some suppliers, requiring work planned for U.S. repair stations to be done in Europe—since EASA certified the aircraft—or elsewhere. But several say their U.S. repair stations are their only options, meaning they cannot work on their SSJ100 components. The suppliers emphasize that while the problem is small—the SSJ100 entered service in 2011—it will escalate as the fleet expands and matures.

Among the possible solutions: obtaining full EASA certification for U.S.-based repair stations, says Karl Specht of EASA's Approvals and Standardization Directorate. This is not the same as an EASA-approved shop based on the U.S.-EU bilateral, however. Those approvals take FAA's certification and apply a set of conditions. A full EASA approval means treating a repair station as if it is on European soil, "with the associated costs and the associated audits," he says. An FAA certification would carry no weight for the purposes of the EASA approval, and the shop would lose all of the efficiency benefits, such as fewer audits, that the bilateral's mutual acceptance creates.

Specht revealed that one U.S. supplier has approached EASA about obtaining a stand-alone EASA airframe rating to install cabin configurations on green SSJ100s. For large-scale work like interiors airframe maintenance, "it makes sense to invest the money" in a stand-alone EASA certificate, he estimates. But for work such as component repairs, "it will never be cost-effective."

EASA and FAA are exploring several options, including authorizing releases that would permit U.S.-based, EASA-approved repair stations to meet only EASA regulations on SSJ100 work.

The problem appears to be limited to U.S. content shipped to the U.S. for repairs. Authorities that oversee the SSJ100's main operators—Russia's Aeroflot and Mexico's Interjet—have certified the aircraft, clearing the way for in-country maintenance at approved facilities. Aeroflot and Interjet combined operate 31 of the 43 SSJ100s in service and have 29 of the 65 on order, Aviation Week's fleet database indicates.

AAR Corp. signed a letter of intent with Sukhoi in 2009 to be part of the SSJ100 maintenance network, but that deal would go forward only if a U.S. operator—which would require FAA certification of the aircraft—emerges.

Specht, citing the SSJ100's EASA approval, offered another option for U.S. suppliers: "You could always have someone in Europe overhaul [components]," he told ARSA attendees. "That's one solution."

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Going Big for The Aftermarket

OEMs and MROs shift their respective focus in pursuit of bigger bundles of next-gen MRO

Henry Canaday Washington

Boeing and Airbus have given much more responsibility to their Tier 1 suppliers for design and manufacture of the new 787s and A350s. Will this consolidation of new aircraft production be mirrored in the aftermarket? Independent shops and engineering firms are sure to feel the ripples.

So far, new-make consolidation is simply nudging the aftermarket in directions it was going anyway. Airlines want more comprehensive support, at least as an option, and OEMs are eager to capture aftermarket revenue and margins.

But all face big challenges on the road to consolidation. It is much tougher than it looks for giant corporations to coordinate just their own internal activities. And airlines want to enjoy the benefits of broad offers while preserving competition in each component market.

Jim Patrick, UTC Aerospace Systems (UTAS) vice president of commercial aftermarket and customer services, says his company has lots of experience at integration. "We try to get our supply chain more integrated and reduce our tail. We look for aggregators for a simple interface and less administration."

NORDAM/JOHN AMATUCCI

A Nordam repair bonder works with composite material in the company's repair division clean room.

Patrick believes UTAS customer airlines want the same thing: simpler supply chains. Of the three levels of aftermarket support—nose-to-tail, system, and component—more transactions are now being done at higher levels.

UTAS provides comprehensive accessory repair and exchange and on-site support. These programs are offered by several business units: Electric, Sensors, Aerostructures, Landing, Interiors, Engine and Environmental, ISR and Space, and Actuation and Propeller. But integrating units takes a lot of processes, tasks and tools. UTAS wants consistent performance across 60 shops across units and the world.

UTAS has a single sales and service force for all the units.

UTAS

A repair technician at UTC Aerospace Systems works on a boost pump at its Miramar MRO facility.

The same services—health monitoring, diagnostics and predictive maintenance—support all products. The OEM inherited long-term contracts from units and is evolving these toward integrated UTAS arrangements. It offers the same kind of contract for every unit, and airlines include as many components as they choose.

Engine-maker Pratt & Whitney is still a "big brother" to UTAS in the United Technologies family. But there are synergies in the electric systems that feed or take power to or from engines and offer opportunities for these brothers to work together.

UTAS performs half its repairs under long-term contracts—flight-hour, fixed-price or otherwise; the other half is time plus materials. Increasing the long-term portion is key.

Interestingly, its Sensors and Integrated Systems unit is taking health and usage monitoring systems (HUMS) techniques developed for rotorcraft and applying them to fixed-wing aircraft. HUMS would cover engines, drive trains, APUs, gearboxes and fans of any manufacturer. Even structural health monitoring of airframe parts should be possible in 3-5 years, says Chris Carella, manager of HUMS strategic planning.

Patrick says the position of independent MROs has not changed much in his market in the last decade. UTAS partners with some major MROs chiefly to ensure its products are well-supported but also to tap surge capacity if needed. "The independent shops will always be there. I don't see any change in competition. At the end of the day, customers will find what they want."

He also predicts independent engineers will stay relevant. "As more materials change and innovate there will be more opportunities for new repairs."

Safran is another aerospace giant trying to maximize the advantages of integration. "We make everything on the airplane except the airplane. And we fix what we fly."

Lengyel also emphasizes Safran's market position: along with partner GE, first in propulsions systems for 100-plus-seat aircraft, Messier-Bugatti-Dowty's leading position in landing gear, first in wiring systems and first in avionics for commercial and military rotorcraft.

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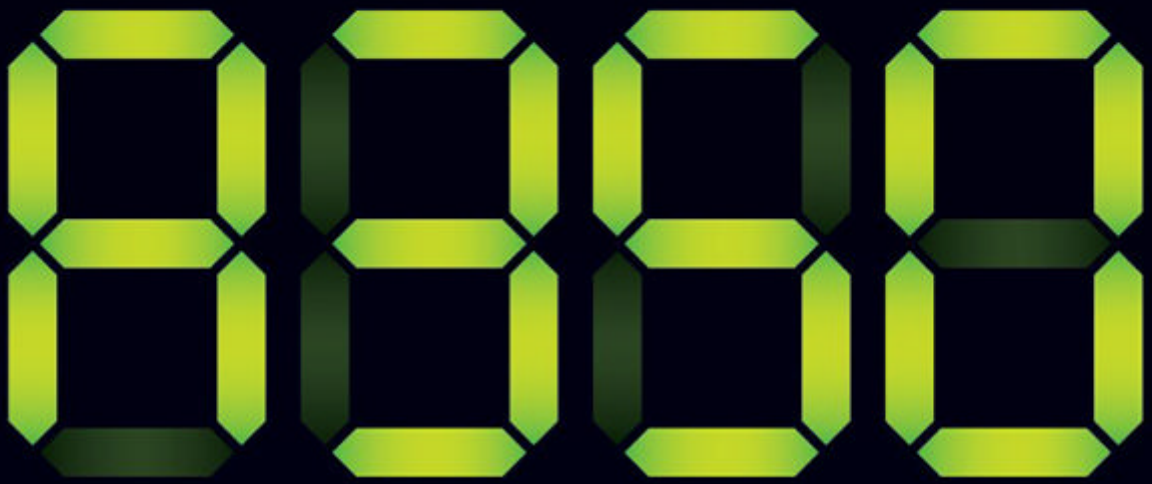

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Lengyel believes long-term relationships benefit airlines in cost and quality. Relationships can be between airlines and one, several or all Safran units. Comprehensiveness of the relationship depends more on how much content Safran has on given aircraft than on whether airframe OEMs consolidated suppliers for original production.

The Safran executive says it has been challenging to harness capabilities of his formerly independent companies, but believes there are benefits. Especially as aircraft require integrated systems and Big Data analytics, Lengyel sees virtues in integration of aftermarkets.

Unit leaders concur. Safran's Messier-Bugatti-Dowty has lots of equipment, landing gear and Chapter 32 components on the 787 and A350, says Alan Doherty, senior vice president of sales and business development. "We support these as a company, but try to harmonize with Safran's other units."

Landing gear is overhauled at 10-12-year intervals and requires expensive equipment and access to rotable gears. These barriers mean gear overhauls will continue to be handled by major airlines or OEMs, as in the past.

For other components, Messier-Bugatti-Dowty offers dispatch-guarantee programs for flight-hour charges. The OEM can also tailor dispatch support to minimize initial provisions, then let the airline gradually build its own spare stocks. Doherty expects flight-hour programs to grow via either Messier-Bugatti-Dowty-only or Safran-wide agreements.

Safran's Aircelle supports nacelles from a shop near Le Havre, a joint venture in Dubai, two long-term agreements with shops in Asia and now with Aircelle Services America, after acquisition of Applied Composites Engineering's (ACE) in Indianapolis. Aircelle long cooperated with ACE. Richard Nevill, vice president of customer support, says Aircelle will purchase, joint-venture with or establish its own Asian shop within 12 months.

The company wants long-term relationships where possible. It dominates A380s and shares A330s with global MROs, but A320 classics are an open market. The firm will aggressively pursue A320neos and A330neos.

Aircelle ownership of its U.S. facility will enable investment and growth, for example by better supporting nacelles on A318s from Latin America and those on Interjet Superjets in Mexico. ASA will also help Aircelle do on-wing troubleshooting in the Americas.

The Safran Group would like to bundle solutions from its different units, Nevill notes. So far, different units have disparate sales teams and contracts with airlines. But contract terms for one unit can be applied to another unit and extend the range of group services

Component repairs increasingly flow through integrators including MROs and OEMs, notes Joel Berkoukchi, executive vice president of avionics at Safran's Sagem unit. Airframe OEMs offer packages, technical expertise, bargaining power with Tier 1 suppliers and capital. But airlines seek used parts

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and new repair processes. Berkoukchi says a breakthrough in coming years might come from PMAs (parts manufacturer approvals) facilitated by 3-D printing and more delegation of authority.

Berkoukchi believes component OEMs can still provide very competitive pricing, fast turn times and management through service bulletins and reliability monitoring, either directly to airlines or through nose-to-tail providers. He says independent MROs will have to specialize in market segments or have the scale to support technology and rotables.

Nordam CEO Meredith Siegfried expects aftermarkets to consolidate as parts become more reliable and require less repair, materials become more exotic and requirements to substantiate repairs become more stringent. "It is critical for independent MROs to have a significant staff of engineers to support repairs if the customer wants anything beyond a basic component-manual repair. MROs need a global presence to fund the heavy R&D effort required."

She says airframe OEMs' consolidation of suppliers of major assemblies may benefit airlines [depending on] "what obligations OEMs impose on Tier 1s to manage aftermarket part pricing and provide access to repair data and engineering."

Siegfried predicts efficient independent MROs will survive, some working with OEMs and Tier 1s. Nordam works with both Airbus and GE. She predicts independent engineers will prosper if intellectual property (IP) belongs to airframe OEMs and they share IP to keep life-cycle cost down. If IP belongs to Tier 1 or component suppliers who do not share, independent engineering will become more difficult.

Cannacord Analyst Ken Herbert argues consolidation may help Tier 1s. He says Tier 1 suppliers have taken more risk on production, which might prompt them to seek more profit from aftermarkets to fund future programs.

John Schmidt, managing director of Accenture's North American A&D business, sees the industry moving to Service 3.0 with the 787 and 350. Selling in this new aftermarket requires much more data and analytics to price parts based on customer value, not just cost-plus. Data and analysis are also necessary for multi-echelon spare planning and to remedy warranty problems. Small shops lack these tool; OEMs lack IP, unless they are behind the "walled garden" of OEM MRO networks, he says.

But other factors work against consolidation. Fast-growing markets like Asia and the Middle East want their own MRO facilities. And in mature markets, "people are certified, not companies," Schmidt observes. Valuable certified people can leave and start a new shop if so inclined. "Consolidation never happens as fast as you think."

Christopher Kubasik, president of the Seabury Advisory Group, sees an overall trend toward consolidation, with its pace depending on the type of maintenance and location.

Repair of major components and line replaceable units (LRU) is becoming more concentrated, with partnerships between major MROs and OEMs and a drive toward pooling, especially in Europe and parts of Asia. OEMs want more control of aftermarkets and are likely to get it for next-gen components. But it is hard for OEMs to do this across platforms without part buying, repair and logistics. Airframe manufacturers will play an increasing role here.

Geography and union rules inhibit consolidation of airframe MRO, Kubasik says. Low-cost regions have been losing their advantage, but the Middle East is attracting skilled labor from low-labor-cost countries.

Engine MRO is already very concentrated, with OEMs and a few large MROs dominating. OEMs will also maintain control of gas-path material repair technology. Peripheral engine work is very fragmented, but main players are likely to continue to gain.

SAFRAN

A-PRO, a Messier-Bugatti-Dowty joint venture MRO in Florida, repairs landing gears and hydraulic components.

Kubasik says drivers of consolidation include airlines' increasing reliance on outsource repairs. Carriers want one-stop shops near main hubs for sensitive items or major and highly efficient repair factories. OEM business goals also matter, and scale efficiencies favor consolidation.

The latest technologies require more investment in R&D, training and licensing, which smaller players cannot afford. And next-gen fleets are more reliable, so now larger fleets are needed to ensure efficient in-house MRO. Standardization of maintenance programs across fleets means outsourcing can be more efficient. Finally, OEMs are simply capturing more of aftermarkets at initial sale.

But Kubasik says MRO consolidation is still inhibited by several factors. Airlines resist outsourcing critical capabilities. And they want to preserve choice and are concerned about possible OEM monopolies. Still, OEMs may be preferred over independent MROs if they offer complete, risk-free coverage.

Kubasik says information technology systems required to manage outsourcing may not exist or require expensive upgrades. And the repair expertise of niche providers is difficult to replicate in large corporations.

For airlines, Kubasik says increased consolidation will mean much heavier reliance on single suppliers, less competition and more standardized solutions. Carriers will also need new business processes as well as more sophisticated procurement, contracting, monitoring and management.

But airlines may gain from reduced complexity, scale efficiency, more predictable costs and possibly higher reliability and part availability.

Independent MROs may gain by consolidating LRU repairs across multiple OEMs, but OEMs will be exerting more control of aftermarket. Independent MROs will need to manage their own IP, such as operational know-how and insights, to be better able to compete. They need to complement OEM offers with unique insights and business focus. Independent engineering and professional firms need to do the same.

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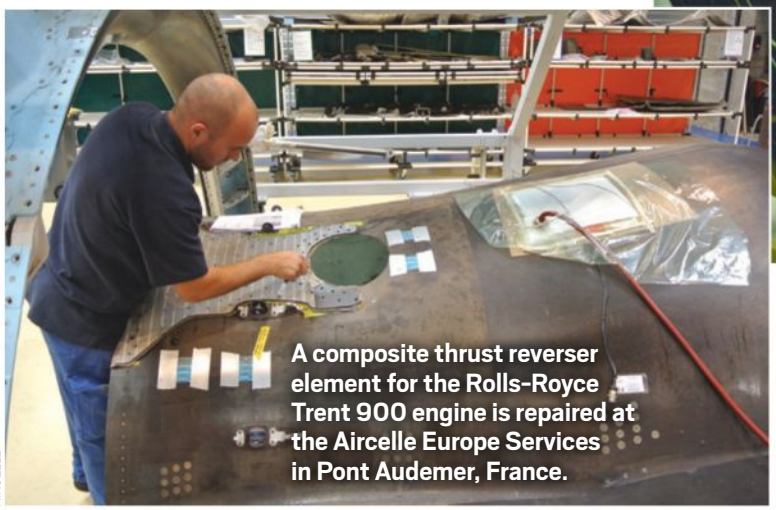
Composite Conundrum

How MROs mitigate material-management challenges

Delta TechOps engineering using the Virtek LPS-7GS laser projection system to design a PW2037 engine cowl fan repair.

DELTA TECHOPS



A composite thrust reverser element for the Rolls-Royce Trent 900 engine is repaired at the Aircelle Europe Services in Pont Audemer, France.

AIRCELLE

Paul Seidenman and David J. Spanovich San Francisco

Composites continue to make inroads on airframe and engine components, but for MROs in the composite structure repair business, managing the exotic carbon-fiber materials and adhesives can be a logistical nightmare. This is because, unlike metal, shelf lives are extremely limited, especially for the bonding agents used in composite repairs. Varying material specifications make multiple repair applications rare, driving costs up. For MROs, this creates a delicate balancing act between having enough material in stock and ensuring the materials' shelf lives do not expire.

"It is extremely difficult to predict the workload, and which materials to order—even on a historical basis," says Leigh Sargent, founder and president of Applied Composites Engineering (ACE), an Indianapolis-based composite component repair specialist. "Since most of the repairs to composite components are due to damage, rather than life limits, you can't plan ahead as to what your material needs will be."

In the composites world, there are two principal materials, Sargent explains. One type, commonly referred to as "pre-preg," is impregnated with chemical resins that hold the fibers together; it is generally used for major repairs on large composite structures. Then there is "dry cloth," commonly used for minor repairs, to which the technician must apply the resin. It's the pre-preg materials—and the adhesives—where shelf-life issues come into play.

"Pre-preg materials have about a one-year shelf life, and the manufacturers—the 'prime' suppliers—normally require large minimum orders—anywhere from $5,000 to $25,000 worth of material," Sargent reports.

The alternative is to order from the so-called secondary suppliers. According to Sargent, there are about five to six companies globally that buy large quantities from the manufacturers and then resell the material in smaller lots to shops, as needed.

"They assume the risk involved with storage and shelf life," he points out. "For the MRO, it saves the high cost of minimum purchases from the primes, and minimizes shelf-life expiration waste."

For those looking to the composite manufacturers as their main supplier, Sargent sounds a cautionary note, especially with regard to pre-pregs. "The majority of materials produced by the primes are going to the aircraft OEMs, because they buy in such large quantities and do not want to stock materials. The result is that the MRO is forced to wait until the prime does a scheduled production run, which could be months after an order is placed."

Mike McBride, director, component maintenance and process and technology engineering at Delta TechOps in Atlanta, stresses the need for MROs to align themselves with composite material suppliers specializing in bulk distribution. But he warns that the customers of these distributors have to be on a schedule—and know their business—because obtaining supply over and above their forecast might be difficult, especially if unexpected shortages happen. "For example, we've seen cases where a batch of adhesive fails the manufacturer's testing and suddenly the whole industry is scrambling to find a solution."

McBride says this is why purchasing schedules must be a step ahead of maintenance schedules, and the best suppliers are ones that allow demand-based adjustments. Reliance on historical data will help—but only up to a point. "While historical data might provide an idea concerning how often a particular repair has been performed on a particular aircraft type and component over the years, you have to factor in unpredictable damage such as a bird strike. Ultimately, it's a crapshoot."

McBride's point was underscored by Ben Clark, senior vice president and general manager at Worthington MRO

Gallery *See a brief guide to composite materials used in aircraft manufacturing:* **AviationWeek.com/CompositesGuide**

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Center, a nacelle repair specialist in Tulsa, Oklahoma.

According to Clark, "a very large portion" of a typical MRO's volume stems from unexpected removals of a very diverse set of products. "Simply put, there is a considerable amount of material requirements that are difficult to plan for," he says. "It could be that a unit [has sustained] what is considered unusual damage, and consequently the company may not stock the materials needed to repair it."

And therein lies the root of the problem, says Clark, who explains that composite products that do not cross over to repair functions performed even semi-regularly are not feasible to stock. For example, he says, it is very common for MROs to use some composite materials only once every 18 months for products they repair on a monthly basis. "While they are performing maintenance on these products regularly, they are not performing the same repairs every time."

Clark agrees that if composite materials required for non-routine repairs have a limited shelf life, it is more difficult to stock those materials because they are consistently thrown away before they are used up. One possible justification to warrant consistent stocking of those materials—and mitigate waste—is very high repair volume. "It is not a matter of planning a larger budget for inventory due to the shelf-life constraints," he stresses. "This will only result in additional waste and higher operating costs."

To ensure that composite materials are available when needed, Clark advises MROs to "work with the airlines for hard time removals of components," and plan repair and overhaul activities many months in advance. "Successful companies will have constant conversations with their customers to have a complete understanding of current trends in their fleet maintenance and be proactive in their planning as well," he says.

Nacelle specialist Aircelle uses its data center's fleet trends to help forecast demand. "That enables us to (monitor) the events that happen on a particular product and know the type of damage that occurs, how often it happens, and therefore what the raw material needs will be," says Jean-Philippe Gremont, aftermarket technical director for the company. "At the same time, if we have a special support contract with a specific airline, then the unique needs of that customer are factored into the material planning," he notes. Materials planning, explains Gremont, is also closely related to the scheduling of its customers' maintenance events. For example, Aircelle's Preventative Maintenance Program (PMP) works with its customers to anticipate possible nacelle maintenance that can be done when the airplane is down for other work.

MROs also need to be cognizant of new technology in composites."You have to position yourself to be ready for changes, not only with the materials, but the materials standards and processes," Delta TechOps's McBride points out. An example is the perforated graphite skin used on newer 737 thrust-reverser panels. "It's a cool new technology incorporated in the manufacturing process, which we have no way to replicate, so we wind up falling back on the older-technology solid panels," he says. "Airlines and MROs will have to have the flexibility to adapt quickly to the new technology and, in many cases, make investments in tooling to ensure they have the capability to make the required repairs. It's a trickle now, but the wave is coming."

One aspect of the new technology is greater damage-tolerance. "As reliability of composites increases, it will mean more on-wing repairs and ultimately less material waste," says Gremont. "As an OEM, we are always trying to identify a balance between performance and direct operating costs."

CONSIDERATIONS FOR COMPOSITE MATERIAL ORDERS

Paul Seideman

When StandardAero Component Services analyzes its composite materials requirements, it considers four factors.

"We start by looking at the specific types of materials we have used, on average, over the past three to six months, along with lead times, shelf life, and our suppliers' minimum order requirements," explains Roberta Savage, senior procurement specialist for the commercial and military engine component MRO. "We also look at how many repairs of a specific kind we did, and the materials requirements."

According to Savage, no orders are placed until this full trend analysis is completed, especially in cases where "high-risk" items, such as adhesives and bonding agents—some with shelf lives of as little as six months—are involved. "Our planning is under constant evaluation especially with regard to film adhesives, which represent the highest risk given their very limited shelf lives."

What complicates matters further, explains Savage, is that many high-tech adhesives have only a handful of production runs per year, and orders must be placed early. As an example she cites FM®57 film, a condensation polyimide adhesive manufactured by Cytec Industries. The OEM produces it four times a year, she explains, at specific intervals, and given demand, it should be ordered two months in advance of production.

"We have to place our order at least two months before each production run. However, when you consider the time we put in to analyze the amount of FM® 57 we'll need, the two-month lead time for the order, and the manufacturer's testing, the whole process could take four to five months before we receive it."

Given the combination of limited shelf life and limited production, Savage reports that standard day-to-day purchasing practices cannot be applied to composite materials, especially when it comes to long-term supplier contracts.

"It's better to negotiate shorter-term procurement contracts of no more than a year in length. Frankly, I'd be very apprehensive even with that, because there's a lot of decision making involved—on the fly."

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Only 7% of 737-800 MRO spending from 2015-17 will be devoted to heavy maintenance

Henry Canaday Washington

The Boeing 737-800 was launched in September 1994, earned FAA certification in March 1998 and first flew with Germany's Hapag-Lloyd that same year. It became the biggest-selling member of the 737NG family and has been continually enhanced, for example with the option of blended winglets. The aircraft's cabin also has had multiple upgrades.

At the start of this year, 3,831 737-800s were flying; 383 more are due for delivery before year-end. Deliveries will continue at a similar pace though 2017, after which they will drop off sharply to barely 18 aircraft delivered in 2019. By the end of that year, more than 4,640 will have entered service.

One characteristic that makes the type popular with airlines is that hangar visits are less frequent and lengthy. In developing all 737NGs, Boeing aimed to reduce airframe maintenance cost 15%, compared with 737 Classics.

Several innovations helped reduce MRO costs. NGs' new wings have nearly one-third fewer parts than Classic wings. Its leading edge was also redesigned for easier maintenance. The main landing gear on NGs is simpler, and the time required for brake changes was cut by 30%. Access to many NG line replaceable units (LRUs) was made easier, and quick-disconnect line fittings were used wherever possible.

In addition, better ground-support equipment was provided, halving the time required for engine removal and installation. NG auxiliary power units were made easier to access and maintain, as were bays for electronics and other equipment. Boeing improved NGs' built-in test equipment (BITE) user interfaces to reduce troubleshooting time and errors.

Boeing NGs use digital cabin-pressure controls instead of analog systems, reducing the number of mechanical parts. This redesign helped BITE more quickly identify problem LRUs or wiring defects, reducing troubleshooting time. BITE also cut this system's mean time between unscheduled removals by three-quarters.

Another NG upgrade integrated stall management and yaw-damper computers in a single unit, improving reliability and reducing maintenance costs. On NG flight decks, Boeing enhanced systems, reliability, redundancy and BITE to increase mean time between failures by 62%.

Even though the 737-800s now require less maintenance, there are still a lot of them out there. Moreover, the first -800s have been flying for 18 years, so this next-generation aircraft is starting to become a senior jet, the kind that usually needs a little more care in the hangar. So maintenance of the 737-800—like that of the more popular members of the A320 family—is big business.

The upshot, according to Aviation Week's MRO Prospector, is that the 737-800 will require about $31 billion in total MRO spending from the start of 2015 through the end of 2019. Of that, $2.1 billion, or less than 7%, will be spent on heavy airframe checks, with the vast majority of outlay for engines, components, line maintenance and modifications. The 737NGs are still, according to Boeing's plan, stingy with the touch labor in C and D checks.

The pace of MRO spending follows fleet size, with a slight lag. Carriers will spend nearly $4.8 billion maintaining the 737-800 this year, more than $6.1 billion in 2017, and nearly $7.8 billion in 2019. Again, more than 90% of this will be spent outside airframe-check hangars.

In 2015, the aircraft will require 848 "C" and 412 "D" checks—for about $313 million—according to estimates by MRO Prospector. C and D checks will account for $418 million by 2017—then climb to $541 million by 2019.

There were 10 airworthiness directives issued by the FAA or the European Aviation Safety Agency from March 2014 through early March 2015, probably indicative of the rough annual pace of extra MRO necessitated by safety regulation for the 737-800. In addition, modifications will be needed for those aircraft that do not yet meet requirements for new navigation and traffic-management equipment where they fly.

Split Scimitar Winglets (SSW) are available for the 737-800, weighing 294 lb. per aircraft and yielding fuel savings of 1.6% on sectors of 1,000 nm, rising to 2.2% at 3,000 nm. SSW requires a trailing edge wedge, strengthened stringers and ballast weight. An upgrade from blended winglets costs about $555,000.

Other modifications will likely be made for passenger convenience.

Recent Airworthiness Directives, Boeing 737-800

Agency	AD No.	Issued	Affects	Effective Date
FAA	2015-02-26	2/18/2015	Fuselage	3/11/2015
FAA	2014-20-06	9/19/2014	Instruments	11/5/2014
FAA	2014-16-14	8/1/2014	Auto Flight	9/23/2014
FAA	2014-17-02	8/13/2014	Communications	9/9/2014
FAA	2014-15-12	7/17/2014	Stabilizers	9/9/2014
FAA	2014-13-07	6/19/2014	Lights	8/19/2014
FAA	2014-13-10	6/25/2014	Fuel System	8/19/2014
FAA	2014-08-11	4/14/2014	Landing Gear	6/3/2014
FAA	2014-05-30	3/3/2014	Stabilizers	4/25/2014
EASA	014-0093R1	9/2/2014	Auto Flight	9/23/2014

Source: FAA and EASA

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Bridging Old and New

Matthew Bromberg leads Pratt &Whitney's aftermarket organization, which supports about 10,000 P&W engines at 20 facilities. At the same time, the OEM is ramping up for production of the geared turbofan, which is expected to enter service in the fourth quarter of this year. He met recently with MRO Chief Editor Lee Ann Shay.

AW&ST: Please describe your operations today.

Bromberg: Pratt & Whitney is at an inflection point. First, Pratt & Whitney's installed base is growing for first time in many years. We are supporting roughly 10,000 engines. But we've sold 6,500 geared turbofans (GTF) and almost 2,000 V2500s—so 8,500 engines in our backlog—and we will start delivering this year. Our backlog is about as big as the installed base. From an aftermarket perspective, that's exciting because up until now, we've been sizing ourselves for a declining installed base—and now we're going to size ourselves for an increasing one.

Another inflection point is that the fleet is going to get younger for the first time in many years. The average age of the PW4000 is 18 years. The V2500's average age is eight years. Another inflection is that we will shift more than 50% of our level of effort to services. For the PW4000, 40-50% of the engines are under fleet service contracts; for the V2500, that is 60% but it will grow to 80%. For the GP7200, it's 75-80% and for the GTF it's 80% under a fleet care arrangement.

How are you preparing for the geared turbofan entry into service?

We are ready on Day One with a global open network to support GTF operators. We have a large installed base, but 40% of GTF customers are new to Pratt & Whitney, so they are new to us, to our field reps and to our network. We want to make sure we're ready to support them across the globe. We have a global network, and that means several things. It means on the line (field support, line maintenance), a 24/7 global operations center, a logistics organization and our MRO network. It's not just P&W that will be ready; it also will be our partners MTU and Japan Aero Engines Corp., so three engine centers will be ready to deal with any early technical issues that arise. That's far more capacity than we'll need because we don't expect the full aftermarket to start until 5-7 years after entry into service. Behind the front lines, we have a network of 15 repair centers tooling up to repair various parts on the GTF engine in advance of when we need it, and stocking spare engines and parts.

Power-by-the-hour contracts are growing, but they can cause consternation . . .

There has been healthy tension in the transactional MRO market for many years. The shop visit itself drives the workscope, then the material consumption starts the tension between airlines and us. That's been going on for 20 years.

PRATT & WHITNEY

MATTHEW BROMBERG

Matthew Bromberg became president for aftermarket at Pratt & Whitney in June 2013. He joined parent company United Technologies Corp. in 2002 and has held several positions including vice president-corporate strategy and development for UTC and vice president and general manager for customer service for subsidiary Hamilton Sundstrand. Before joining UTC, Bromberg was an investment banker for Goldman Sachs and a nuclear-training submarine officer in the U.S. Navy.

Over the past 10-15 years, these fleet-care programs have risen in popularity because they provide risk reduction for the operators and they align incentives between the operators and us. We don't want the engine to go into the shop—neither do they. Fleet care programs try to keep engines on wing longer because engine swaps are disruptive to logistics, stands, tooling etc. It's an important risk-transfer proposition.

As power-by-the-hour agreements become more sophisticated, there's an area of tension developing between the OEM and the operator. In the ideal world, the operator will pay a dollar-per-hour rate and leave it up to us to maintain it. But in reality, many operators want to dictate removals or become involved in the workscope of the engine. That creates tension because if you're not going to transfer all of the risk and give up the flexibility you had with a transactional model, you're not exactly subscribing to a full power-by- the-hour agreement. We work through that every day—and I tell operators I'm happy to yield back certain flexibility but then they have to take back some of the financial risk if they're going to dictate removals or workscope. In some cases, operators are migrating back to a transactional model, if they want to be more involved. There's an interesting pendulum going on.

Where will the power-by-the-hour agreement pendulum end up?

I think airlines will bifurcate—some will migrate to full power-by-the-hour agreements where we take on all the risk, and at the other end of the spectrum, you have a full transactional model where they make all of the decisions and we'll support them. Then there will be this third variant, where if they add risk to the equation and want flexibility, we can accommodate that; but we just have to charge for that in the rate.

The reason we need flexibility is because that's how we optimize the rate. If you have the flexibility of when the engine comes off and to which engine center it goes and the workscope that goes into it, you can optimize the rate so it's most cost-effective. If you start putting constraints on it, we can handle it, but it's going to add costs to the overall program.

When you took on this role, you started realigning the aftermarket organization to one P&L. Where are you with that?

We had 24 different profit-and-loss centers—and that made sense if you think about how the aftermarket evolved. It was a transactional model. Some customers came through an engine center and others were buying spare parts. As

you shift to a full-service model, customers have one contact manager and they expect everything to act behind the scenes. So when you want everything to operate seamlessly behind the scenes, you don't want individual P&Ls that are trying to differentiate between internal transfer and internal transaction versus an external transaction. It was designed as a two-year transformation—and we're about halfway through.

What are the results?

We started with the Singapore engine center—the PW4000—last year so that's about 6-9 months ahead of the others. We already reduced our turnaround time on the three variants on average 15% last year. We had a target of 20% over the two years and we're well on track to meeting or exceeding that this year. For the PW4000, which is in its last 10 years of life, operators have a lot of choices, and now we're able to compete aggressively and win in that transactional market, too. We're winning back transactional customers and we're maintaining 45% of that under power-by-the-hour agreements. We're making customer-centric decisions that we normally couldn't do because the P&Ls were not necessarily aligned with the customers—from spare engines to used serviceable material. I'm very pleased with the progress. The piece we need to finish is the IT rewiring, which we'll start this year.

How are you using engine data differently?

We are accumulating more and more data from the engines, and we're going to provide for the first time the business intelligence that the industry requires. We've been scratching at this for years, and I think technology is converging to the point where it's going to happen. Technology is coming from several dimensions: Engines are generating more data; the ability to store that data has increased exponentially; and the ability to process that data real-time has emerged.

We announced a collaboration with IBM last year that is accelerating our ability to monitor fleet care agreement engines and use that data for the enhancement of the engine operations. We built a model with IBM that can predict inflight shutdowns to 99% accuracy looking forward 12 months.

As the OEM, we will have all data and underlying intelligence capability to use that data for business intelligence. For instance, we can look at city-pairs for which an engine is operating and we can look at the influence of the city-pair on the engine maintenance. That's important for three reasons: We can give that guidance back to the operator; we can bake it into the rate that we're charging for service agreements; and we can optimize maintenance around that engine. It becomes a full circle—we can use this data to provide you the best rate and optimize engine performance. We call it Pratt & Whitney Intelligent Workscopes. Big data allows you to correlate the impact of data parameters.

Keeping It Local

Rolls-Royce departs from business as usual as it moves real-time support out of the U.K. to Singapore

Jeremy Torr Singapore

As part of its expansion in Asia, Rolls-Royce has opened a customer service center in Singapore, which means for the first time the engine manufacturer is basing critical, real-time support efforts outside of its headquarters in Derby, England.

Dominic Horwood, chief customer officer for civil large engines, tells Aviation Week that the move was driven by the volume of business in Asia and the realization that companies there want local, dedicated and culturally aware support—not instructions from an office halfway around the world and several time zones away.

With services providing 60% of the company's overall income from its civil engine program, that makes sense. "Rolls-Royce is working on understanding and responding to our customers' [local] needs better," Horwood says. "And this new facility in Singapore is the beginning of those efforts to get closer to customers."

The center will provide real time powerplant monitoring for a range of carriers including key local customer Singapore Airlines and the expanding numbers of long-haul low-cost carriers in the region, says Eric Schultz, president for civil large engines.

As well as the normal local support and parts functions, the center will help diagnose and mitigate potential problems by using predictive data analysis and localized fleet management based on regional MRO availability and network schedule scope. Center staff are targeting a problem-solving rate of 80% for most customer issues, says Ewen McDonald, senior vice president for Asia-Pacific.

"This is our fastest growing region. So our big push is to generate local expertise, to make local decisions," says McDonald. As part of this, the center will extensively use smart data analysis to solve issues, but it will also be hot-linked to the Derby headquarters for particularly tricky problem-solving.

ROLLS-ROYCE

Service engineers are able to track Rolls-Royce powerplants on Asian aircraft, in real time, anywhere.

"We have never done all this before in one place—engineering, service, sales and business, and data management operations. This is a real first for us, and it is vitally important to the company," adds McDonald.

The center also will act as a testbed for the company's drive to improve the skills of local and regional decision-makers. As the first in what the company is planning to be a network of dedicated service centers, regular working methods are not a given, says Horwood.

"People don't have set desks and places they work from," he explains. "We encourage people to gel together in spontaneous teams to sort out individual customer issues instead, not just sit there and look at a screen or email."

"We want to think slightly differently here. We are pushing for behavioral collaboration, for deliberately short meetings, for a kind of 'smart water-cooler' effect."

Horwood notes that the use of massive screens with real-time data readouts from all of the company's local products worldwide encouraged teams to come together as needed on issues—not simply operate in a procedural way.

He says the center's role as providing a learning exercise for the development of systems and problem-solving is also crucial. Lessons learned will be applied when the company opens the next of four planned new service centers; No. 2 will be in the Americas.

The new facility, situated next to the Rolls-Royce Trent engine manufacturing plant at Seletar Aerospace Park in north Singapore, will have a staff of around 50 by the end of 2015.

About 20% of all Rolls-Royce's large engines are based in Asia, so trying to manage such a fleet from just one center in Derby raised operational and cultural issues. Most significantly, at least 50% of the new center's staff will be Singaporeans or other Asian engineers or systems experts, says Horwood. All will be fully trained in engineering services and operational support.

"That means this new center is not about the money that we spend on it, it's about the people we can put here," he says. "Singapore is now a true hub for us in Asia. We do engine assembly, delivery and parts and service, all from the one location," he says.

Schultz underscores the importance of the new center for the future of Rolls-Royce in the region.

"Years ago we were set to fail, but we drove back because we believed in the product and company," Horwood admits. He says that drive to keep moving forward has helped the company to take a new look at the way it works.

"We thought recruiting the right people, who think differently, might have been a challenge here in Singapore—but it wasn't," says Schultz. "We were impressed with the number of young, agile, smart-thinking [local] applicants who accepted that commitment was more important than status."

As part of that ethos, the CEO has an office, but rarely uses it. With the result, hints Schultz, SIA looked at Rolls's new unstructured work processes and was considering introducing some into its workplaces.

"Our goal is to perpetuate the quality of our product throughout the entire life [it is in the air]. And service excellence, like we are pushing here, is part of that," adds Schulz.

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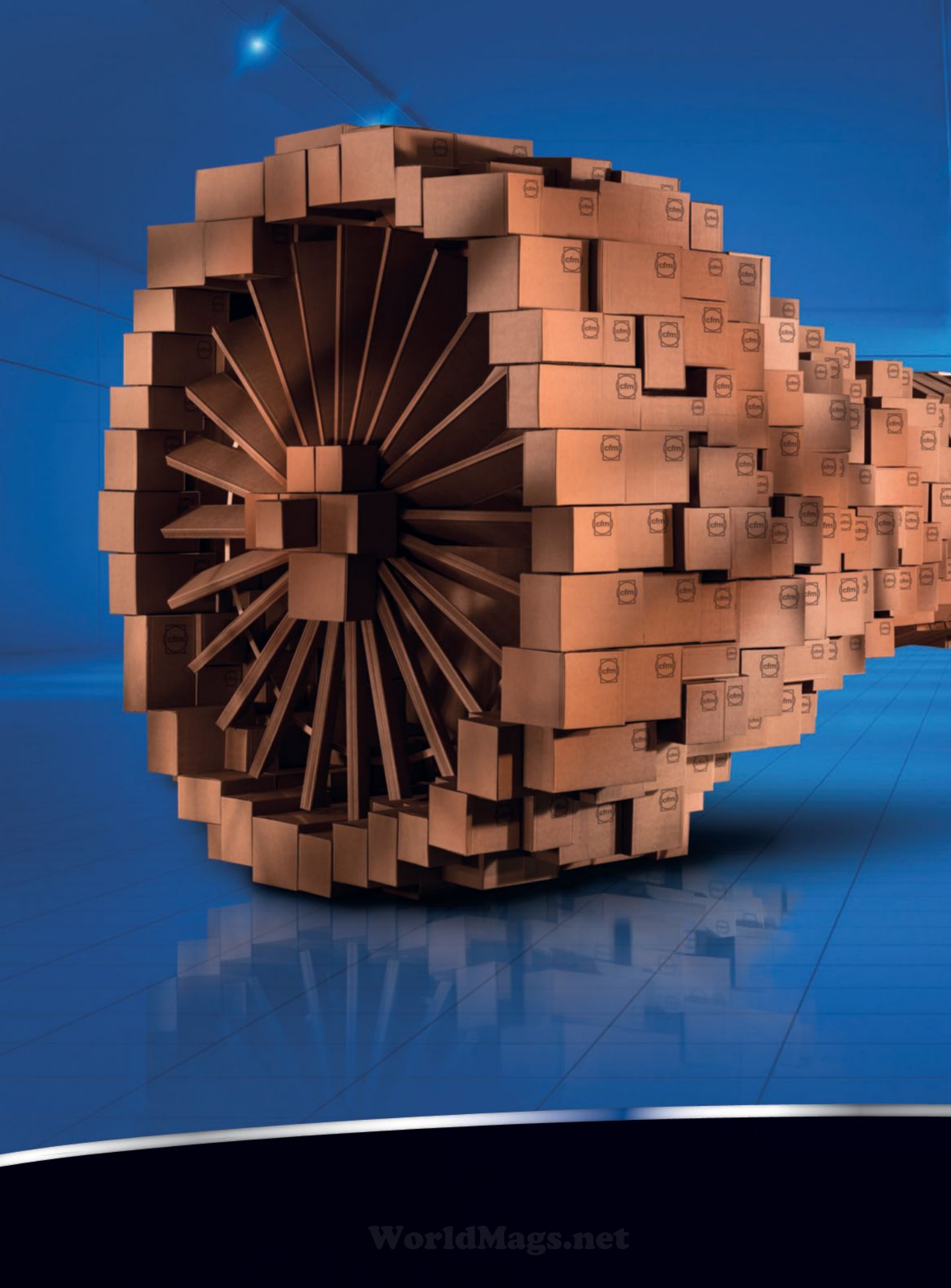

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Washington

Culture Change

The FAA's plan to use its new data-driven surveillance system to reduce audits should not encounter much resistance from airlines and repair stations, which spend too much time having different audit teams review the same information. But for members of those audit teams, the shift may not be so smooth—and the agency's top executives know it.

"The hardest thing about this isn't the mechanics or logistics," says John Hickey, FAA's deputy associate administrator of aviation safety. "It's going to be cultural."

The Safety Assurance System (SAS), which debuted last June in the certificate management office (CMO) responsible for Delta Air Lines, is designed to standardize risk management by allowing FAA to collect and share audit data internally. It serves as the safety assurance part of FAA's internal safety management system (SMS) for its Flight Standards service, complementing the other three parts of an SMS: safety policy, safety risk management and safety promotion.

SAS is becoming the primary surveillance system for airlines flying under Part 121, operators covered by Part 135, and Part 145 repair stations. Eventually, it will be rolled out to cover more certificate holders. FAA manages more than 7,300 certificates, including 4,000 repair stations. An internal FAA tool, SAS imposes no new requirements on industry.

SAS is the key plank in FAA's platform to boost risk-assessment while cutting the number of audits. Yet fewer audits mean less hands-on work for FAA staffers whose job it is to ensure certificate holders are complying with the regulations.

"A principal [inspector] of a CMO for an airline takes that [role] very personally," Hickey told MRO executives at the Aeronautical Repair Station Association's annual meeting in March. "If something goes wrong, they hold themselves accountable."

STANDARD AERO

Repair stations stand to benefit significantly from FAA's new oversight system that prioritizes reducing redundant audits.

Under the current system, a repair station with 10 airline customers can expect regular audits from at least 11 FAA teams—one from each CMO that oversees its customers, and one from the FAA office that oversees the repair station. SAS aims to change that by allowing results from one audit to be shared, avoiding duplication of effort that serves no purpose.

"Audits are good, but you can have too much of a good thing," Hickey told the MRO executives. "The number of audits that you're being asked to handle is going up, with no risk-based data decision-making to support safety or efficiency. We can't have that."

The system is designed to help inspectors collect information, spot trends, and focus surveillance on the areas that need it most. Data collection can be supplemented by operators, who will be able to enter their own data into the system via a web portal. The objective: Combine FAA-collected observations with information provided by certificate holders such as through established Aviation Safety Action Program initiatives, to help pinpoint where additional surveillance is needed.

"We will focus on risk-based inspections supported by data, in lieu of random or calendar-based inspections," Hickey says. "The end-game here is to put an end to an auditing philosophy that is based on the principle that 'we do it this way because we've always done it this way.' Why do I need to do inspections of five critical performance elements where I've never seen a finding from this airline in 10 years? We're now going to have the authority and the orders to support the inspections that made those decisions."

Long-term, Hickey says SAS should allow inspectors' work to go further, which could have particular significance for repair stations, which work for multiple certificate holders. But getting there will require inspectors to trust in the system—which means placing trust in each other.

"When a CMO in Texas has aircraft being maintained in Oklahoma, we are going to have to get them to understand that they may not be the ones who go up there and audit the repair station," he says. "It may be a locally based group, or a combination team, with representation from" the airline's primary oversight office.

Hickey is confident that heeding lessons learned from previous efforts to revamp oversight will help ensure a smooth introduction for SAS. When the Air Transportation Oversight System was rolled out in the late 1990s, for example, the agency didn't provide adequate training for its inspector workforce.

"We created the system and simply threw it out in the field," Hickey recalls. "It took at least 10 years for FSDOs to come to grips with it. We're not making the same mistake with SAS."

FAA plans to roll SAS out to its CMOs and Flight Standards District Offices (FSDOs)—about 100 field offices in all. It is up and running in about 30 offices, says Steve Douglas, manager of FAA's Aircraft Maintenance Division.

Aside from the reduction in audits, the shift should be all but transparent to industry, Douglas says. FAA offices that roll out SAS are supposed to send letters to the certificate holders they manage, informing them of the change and the availability of the new web portal.

The portal's use will be woven into guidance to help industry comply with certain regulations. First up: allowing airlines to use it to submit updated lists of third-party maintenance vendors, which is part of the agency's recently introduced contract maintenance rule. FAA says data formats will be standardized and simple, allowing industry to use familiar tools like Microsoft Excel to submit data to the agency.

The FAA's ambitions go beyond streamlining its own processes. Douglas says the agency has had "early discussions" with European Aviation Safety Agency officials about working together to reduce audits among commonly certified repair stations. FAA has presented several papers to international conferences on the issue, notably at February's International Civil Aviation Organization's High-Level Safety Conference.

FAA STARTING PART 147 UPDATE

The long-needed revamping of FAA's Part 147, the rules governing U.S. aircraft maintenance technician (AMT) schools, is underway, says the FAA's Steve Douglas.

Part 147 lays out the minimum curriculum for AMT schools, such as how many instructional hours must be spent in specific areas. Updating the standards, largely untouched since 1970, is now "a priority" within the agency's Fight Standards group and drafting of the proposed rule has started.

Douglas says one change in the new rule will be moving the curriculum requirements into Operations Specifications, where they can be changed quickly, as opposed to leaving them in the regulation itself, which is harder to change.

Outdated curriculum requirements are one of the main complaints industry has about the current Part 147.

—Sean Broderick

Europe

Better Basic

Europe is working on changes to its regional aviation regulations that include pooling resources across countries to help ensure technical tasks—like certification and continued airworthiness—have adequate resources region-wide, a European Aviation Safety Agency (EASA) proposal reveals.

The "opinion," published in March, is the next step in EASA's effort to "update and improve" its Basic Regulation, an overarching framework that defines the 12-year-old agency's roles and responsibilities. EASA, in charge of most civil aviation safety regulatory activity for the 28 European Union member states plus Iceland, Lichtenstein, Norway, and Switzerland, crafted the document based in part on feedback from 6,000 industry stakeholders. The proposal suggests several notable changes beyond resource-sharing, such as enacting oversight for ground-handling service providers (GHSP), and modifying how EASA is funded.

Commenters made clear that resource limitations at some member states are hampering fundamental tasks like staffing "competent authority" (CA) inspector workforces, which are being strained by growth, such as low-cost carriers tapping new markets.

"EASA proposes to amend the Basic Regulation in order to facilitate the voluntary and temporary (i.e., non-irreversible) transfer of responsibilities and tasks horizontally between CAs, but also vertically from CAs to EASA," the agency explains. "This flexibility would allow for a certain level of specialization at CA level, as each CA could take over the performance of one or more responsibilities and tasks from several other CAs and become a regional 'center of expertise' with an adequate work volume."

The agency will also explore taking a more active role in coordinating cooperation among CAs. Examples include developing best practices and common standards for use at the member-state level, and could expand to include creating a pool of inspectors "mutually accepted and used as-needed by all CAs."

EASA emphasized that resource-pooling and transferring of tasks "would require a solid legal basis for its funding, and should allow for the reliable, long-term planning for all involved parties." Revamping EASA funding could include tapping additional funding resources, ranging from overflight fees to passenger contributions, EASA suggests.

"As [air traffic management] regulatory activities are transferred from Eurocontrol to EASA"—per a 2009 regulation—"the funding and its mechanism should be transferred too, while the total amount of airspace user contributions should not be affected and even diminished through efficiency gains," EASA adds.

EASA suggested that, long-term, "a more comprehensive reform of the current funding system—in which regulatory costs are borne at EU and national level in a fragmented, sometimes ineffective and even unfair manner—would help overcome many shortcomings as identified in this Opinion."

A majority of commenters "see unaddressed safety issues" in GHSP, and believe that including the subject in the Basic Regulation would fill "a significant gap, as there are currently no safety rules at European level to cater for these providers," EASA notes. Air carriers are more hesitant than the general population, noting "a natural interest" to promote safe operations and expressing concern that "overly detailed technical rules and possible stringent future certification requirements" could lead to unnecessary complexity.

EASA suggested that a more measured approach could leverage industry best practices to "create a well-measured legal and enforceable obligation rather than to introduce technically new requirements."

NIGEL HOWARTH/AW&ST

Ongoing trends—such as low-cost carriers expanding into new markets—are straining oversight resources in some European countries.

The agency also pledged to continue developing data-driven, performance-based regulations, but would not abandon its traditional prescriptive approach completely. EASA also will explore common "repositories" for organization approvals, personnel licenses and aircraft registries. While the registrations and official records would remain at the member-state level, common database standards would be created, "transferred to EASA and . . . updated on a regular basis." The agency would manage the central repositories.

EASA sought input on a European-level aircraft registry, but commenters favored the middle ground of keeping the official records at the member-state level and creating a centralized database. This would help interested parties "follow the airworthiness or ownership of aircraft in the EU" and "support CAs in their oversight and monitoring functions," EASA reasons.

The body notes that implementing EASA's general aviation (GA) road map is a key priority to help simplify rules for GA manufacturers and operators. The agency also expects its authority to expand to cover unmanned aircraft systems, or "drones," in EASA-speak.

"I believe that although our proposals are ambitious they are also reasonable, says EASA Executive Director Patrick Ky. There is nothing wrong with being ambitious about safety."

EASA's opinion will be sent to the European Commission, which will use it to develop an amendment—due out this year—to the Basic Regulation.

—Sean Broderick/Washington

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Regina Kenney Chicago

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Applications: SolutionsProgram
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www.afiklmem.com

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Applications: Repair and overhaul (SCM)
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Applications: Airframe MRO services
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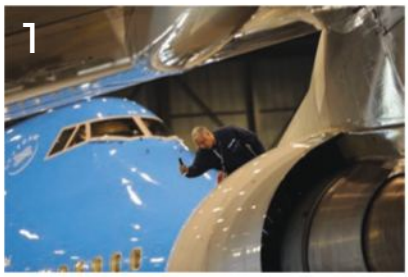

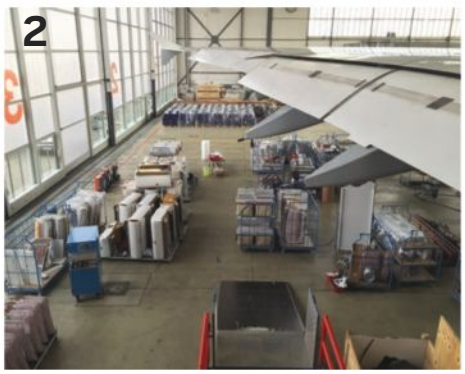

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Applications: Integrated supply solutions
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www.wesco.com

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5. Services for MRO life cycles

Manufacturer: Production Services Management Inc.
Applications: Integrated supply management for MRO
Specifications: PSMI's integrated supply management for MRO items offers a wide variety of services in the MRO life cycle. The company provides market insights for sourcing as well as an enterprise resource planning system that optimizes purchasing processes to obtain the lowest prices for the supply base that automatically manages price breaks, freight minimums, seasonality of demand, blanket purchase orders, lead times and demand. It also includes inventory, warehouse/crib and supplier management, and accounts payable.
www.psmicorp.com

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Manufacturer: **SDI**
Applications: Innovative MRO software and technology
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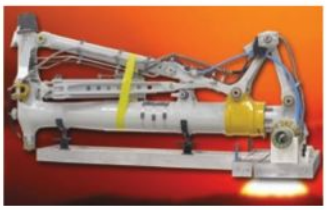

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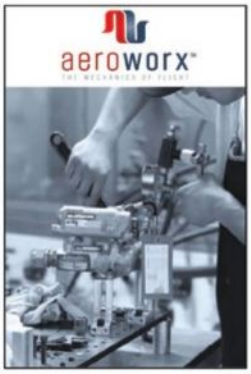

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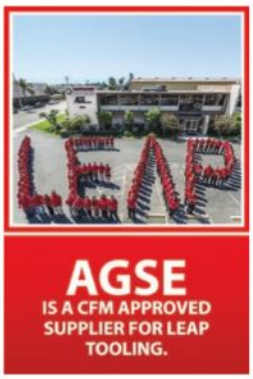

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AST provides laboratory services and systems to measure residual stress. We specialize in Non-Destructive testing for thermal damage through chrome according to SAE ARP 4462. Our technologies include x-ray diffraction, hole drilling, ESPI, Barkhausen noise. Products: XStress, Rollscan, Prism.

Landing Gear/Wheels/Brakes ▪ Engineering ▪ Engines ▪ Metals ▪ Test Equipment

www.astresstech.com

Link 1098

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AMETEK TAYLOR HOBSON

Surface, Form, Roundess and More

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Taylor Hobson, a global leader in ultra-precision measurement instrumentation, has further expanded the capabilities of its Talysurf family of metrology instruments with the launch of the Talysurf Optics 3D. Based on the established PGI Blu, the new PGI Optics 3D offers the combination of a wider range of part diameters, up to 200 mm, with new features supporting 3D measurement.

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www.taylor-hobson.com
Link 1099

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Worldwide OEM Distributor Global Supply Chains Custom Tailored Support Services

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www.ansettspares.com
Link 542

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Apollo Performance Gloves
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Where Your Safety is Number One!

Airport Equipment & Services ▪ Fuel/Lubricants ▪ Safety/Emergency Equipment

www.apgloves.com
Link 1085

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Advanced Composites & Adhesives

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Associated Industries, Inc. is an established supplier of adhesives, sealants, vacuum bagging material, core, and advanced composite materials to the MRO and OEM aerospace markets. Centrally located in Wichita, Kansas, Associated can support any customer needs throughout North America.

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www.associatedindustriesinc.com
Link 1100

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ADSE 743 Pitot static test set RVSM compliant capable of altitudes of 60,000FT/ 6000ft/min. Large touch screen display enables all tests to be carried out easily from the flight deck or cockpit, by a single operator.

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www.ateq-omicron.com
Link 822

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Aircraft MRO, Cabin Integration, Wheels & Brakes

BOOTH 1602

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www.avianor.com
Link 1101

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AVIATION PLUS INC

Instruments, Avionics, Accessory Repair & Overhaul

BOOTH 3150

Aviation Plus Inc, founded in 1986, is an FAA/EASA repair station certified in classes I, II, III & IV Instrument repair, Accessory Class III and Limited Radio. Our overhaul capabilities cover commercial, military, helicopter, commuter and corporate aircraft.

We offer FREE evaluations and 24 hr. AOG

www.aviationplusinc.com

Avionics/Instruments

Link 1102

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The People and Products
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Service and support from the OEM that built it:

-Engine Controls
-Flight Controls
-Flight Deck Systems
-Cabin Systems and Modifications

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www.baesystems.com/ commercialsupport

Link 060

BASF

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www.aerospace.basf.com

Link 316

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Turbine Engine MRO & Field Services

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www.bischoffaero.com

Link 1103

BP AERO SERVICES

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Link 395

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www.powerbreezer.com

Link 1132

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BROWN AVIATON TOOL SUPPLY CO

Stocking Supplier of Speciality Aircraft Tools

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Link 272

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Inflatable Hangars: Large, Safe, Portable!

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Our last outstanding projects:
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Airport Equipment & Services ▪ Engineering ▪ Hangars & Equipment ▪ Military Maintenance ▪ Third Party Maintenance

www.buildair.com
Link 760

CALICO LADDERS LLC

Leading in Fall Prevention Safety

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With over 35 years of industry experience, Calico Ladders offers a full line of specialty application ladders. With aviation being one of our largest selling industries, we offer a wide variety of pre-engineered solutions as well as custom options to meet all your ground support needs.

www.calicoladders.com/featured-products/aircraft-pylon-access-ladderhtml

Ground Support Equipment

Link 1104

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www.canrep.com

Components

Link 1105

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Airframes ▪ Components

Link 1106

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www.CarlisleIT.com
Link 543

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Cases Shipped Fast and Built to Last

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CDC is a US manufacturer of shipping, transit and soft cases. We produce cases for maintenance, repair, calibration, and component logistics in the avionics industry that conform to ATA Spec 300 Cat 1 requirements. We custom build cases and bags to your specifications or order from our stock.

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www.casedesigncorp.com
Link 1107

CEL AEROSPACE TEST EQUIPMENT LTD

Building Test Solutions

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CEL Aerospace newly appointed as Honeywell Test Cell Manufacturer

Engineering ▪ Engines ▪ Ground Support Equipment ▪ Test Equipment ▪ Tools

www.cel-aerospace.ca
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Stocking Distributor Providing Inventory Management Programs

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Century Fasteners Corp. is an ISO9001 and AS9120A certified supplier of Hardware, Fasteners & Electromechanical components. We stock, manage and distribute high quality products to Aerospace, Medical, Military, Automotive and commercial manufacturers.

For product quotes please call 1-800-226-6644.

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www.centuryfasteners.com
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High-Production Soda Blasting

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Aerolyte® Soda Cabinets address 21st century production requirements with unique ventilation and powerful dust collection for superb visibility. These cabinets address the special challenges of high-value, complex geometry components for coating removal and general cleaning in a production setting.

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Link 081

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www.cobham.com
Link 273

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Hangars & Equipment ▪ Parts Distributor ▪ Parts Manufacturer ▪ Software ▪ Supply Chain/Logistics

www.componentcontrol.com/quantum1/index.html
Link 083

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COMPONENT OVERHAUL SERVICES

Your One Stop Component Repair and Overhaul Shop

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Repair Station specializing in landing gear, accessories, and airframe repair and overhauls.

Flexible pricing and quick turnaround times to meet customer demands.

Landing Gear/Wheels/Brakes

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www.dcm-tech.com
Link 1111

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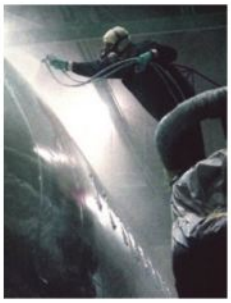

For over 50 years, Dean Baldwin Painting has been providing expert aircraft refinishing services to the aviation industry. Our well trained and experienced staff of 400 professionals will provide a broad range of services including, full strip and paint, flight control balancing, scribe line inspections, minor maintenance, aircraft weigh and custom liveries for VIP, Airline and Military customers. From our 3 locations – Arizona, New Mexico and Indiana, We Create The Standard.

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Link 090

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We buy your excess expendable & consumable inventories!

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Link 756

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Extensive capabilities include the repairs, sales and exchange of the following components: IDGs, CSDs, Starters, Generators, Pumps, Motors, Valves, Actuators and many other Pneumatic, Hydraulic and Electronic accessories.

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www.EMCAerospace.com
Link 097

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Economic Development

Link 1113

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Hangar & MRO Design Leaders

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FSB Architects & Engineers is a nationally recognized leader in the planning and design of aircraft hangars and MRO facilities. We are a full-service design firm that has recently designed 200 hangars valued at over $3 billion. Download our FREE APP containing aircraft information: "FSB Aviation."

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www.fsb-ae.com

Link 1114

FURNACE PARTS LLC

Are Your Thermocouple Specifications Critical?

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Furnace Parts is an ISO certified manufacturer of a vast array of customized thermocouples and sensors that meet the exacting needs of the aerospace market. Be it compliance to Nadcap or other specific prime pyrometry requirements, we understand your critical temperature measurement requirements.

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www.furnacepartsllc.com

Link 1115

GA TELESIS

Your Nacelle Program Specialists

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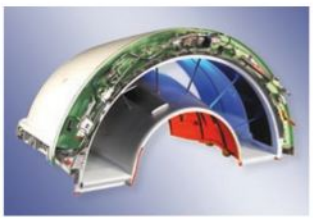

Exchange & overhaul support for complete thrust reverser systems, including actuation. Accessory capability includes hydraulic, pneumatic, power gen, electro-mech, and electronics. Limited airframe capability includes cockpit windows. Certifications include FAA, EASA, CAAC, ANAC and more.

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Link 111

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If you exit the platform, JLG helps keep you safe and mobile with a Fall Arrest Platform. These platforms use a cable system that allows the operator to leave the platform and move freely without detaching the safety harness. This helps keep the operator tethered to the platform at all times.

GCIron.com

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Components

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Hangars & Equipment

Link 345

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Key Features include:

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www.globalparts.aero

Link 850

HARCO

A320 Landing Gear Harness Repair

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www.harcolabs.com

Link 121

HASKEL INTERNATIONAL

Gas Booster Transfer and Charging Systems

Gas Booster for systems charging or topping up gas pressures ensure optimum use of bottled gases as low as 150 psi while producing pressures as high as 39,000 psi. Gas carts for transfer, charging, testing, calibration or tool operation. Oxygen systems for filling oxygen. Pumps for aircraft jacks.

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www.haskel.com

Link 1037

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Global Support, Asset Availability and Aftermarket Solutions

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Honeywell reduces total life-cycle cost through products and scalable aftermarket solutions. Advanced support services allow operators to manage and predict maintenance spending, while our 24/7 global support ensures your flights are running on time.

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aerospace.honeywell.com

Link 128

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www.hydro.aero

Link 718

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Iberia Maintenance & BAE: Stronger Together

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MRO services for B737, 747, 757, 767, 777, 787, A300, 320, 330, 340 & 380. Overhaul, repair, exchange and test of the instruments, accessories and components assembled in these fleets. Iberia Maintenance offers engine process on CFM56-5A1/-5B/-5C4, CFM56-7B, V2500, RB211-535E4/-C & CF34-3A/B & APUs.

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Link 747

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IDA Ireland is the Irish Government agency with responsibility for securing new investment from overseas companies looking to expand their business internationally.

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www.idaireland.com

Economic Development

Link 1118

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Software

Link 1119

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Supplier and Repair Station of Choice

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Link 547

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INFORM specializes in advanced optimization software used by the world's leading airlines. Our portfolio includes dedicated workforce solutions for line/base maintenance organizations looking to increase their productivity and aircraft availability and to improve their quality while reducing costs.

INFORM

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Consulting Services ▪ Software

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www.janacorp.com

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Link 1121

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Manual Revisions and Audits Made Easy

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Link 1122

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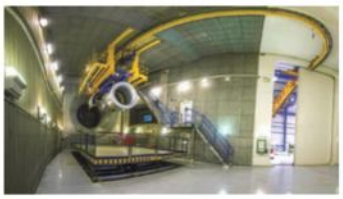
Engine Capabilities - CF6-80C2 - CFM56-3 - RB211-524 - CFM56-5B (End of 2015)

- Full Overhaul Capabilities
- On-Wing Support Services
- Engine Tear Down / Parts Consignment Programs
- Engine Lease & Exchange Services
- Engine end of lease inspection & Back to Service Release



http://www.jordanairmotive.com/PhotoGallery.aspx?lang=en

Engines

Link 1043

JSFIRM.COM

The Most Recommended Aviation Job Website

BOOTH 132

JSfirm.com is the most recommended aviation job website with resume database access. JSfirm.com is a free website for job seekers and a place for aviation companies to advertise jobs and search resumes.

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Maintaining legacy fleet is increasingly difficult as aircraft are retired and supply chains dry up. Souring, supplying and manufacturing legacy parts is ingrained in our heritage.

We provide global support for many out-of-production Aircraft/Engine types. Contact us today!

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Airline & MRO Spare Parts & Supply Chain Services

BOOTH 3826

Kellstrom Materials delivers cost-effective spare parts and supply chain management support. Services include new OEM and pre-owned parts distribution, AOG and JIT support, consignment management, repair management, overhauled rotable components, whole engine assets, and fleet provisioning programs.

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www.kellstrommaterials.com
Link 830

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New Name. Same Great Partner.

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KLX Aerospace Solutions (formerly B/E Consumables Management) is the leading supplier of aerospace fasteners and consumables and full service solutions provider for the aviation industry. Interturbine is a leading supplier of raw & semi-finished metal products, chemicals, and composites.

Chemicals ▪ Hardware ▪ Lighting ▪ Parts Distributor ▪ Tools

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Link 1124

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L-3 Aftermarket Solutions. At Your Service.

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L-3 Aviation Products is a global provider of Aftermarket Solutions to the commercial aerospace and defense sector. Our capabilities include Avionics MRO, Integrated Logistics Support (ILS), Technical Services, Supply Chain Management and Ground Support Equipment. Visit www.L-3com.com/AviationProducts.

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LANDING GEAR TECHNOLOGIES LLC

"Fine Workmanship and Attention to Detail"

BOOTH 2643

Landing Gear Technologies is an independently owned company specializing in the repair and overhaul of landing gear systems and a variety of other components. Our motto "Fine workmanship and attention to detail" is what we strive to offer every customer who entrusts us with providing our services.

Components ▪ Hydraulics/Pneumatics ▪ Landing Gear/Wheels/Brakes

www.LGT.aero
Link 415

LEKI AVIATION INC

Aircraft Parts Distributor & ATA 25 Repair Station

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Leki Aviation specializes in the supply and distribution of aircraft parts, interiors and components to the global aviation industry.

Leki's 25 Repair Centre is dedicated to offering economical, reliable and quick solutions for the supply and recertification of chapter 25 material.

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www.lekiaviation.com
Link 258

LEWIS & SAUNDERS

Overhaul & Engine Repair Tubing

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Airframes ▪ Components ▪ Engines ▪ Metals ▪ Third Party Maintenance

www.lewisandsaunders.com
Link 297

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LockNClimb, LLC aviation ladders provide enhanced safe ergonomic standing platforms for corporate jet and commercial aircraft MRO facilities. Heights ranging from 4' to 15'. GSA #GS-07F-080CA.

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Airframes ▪ Landing Gear/Wheels/Brakes ▪ Military Maintenance ▪ Safety/Emergency Equipment ▪ Tools

www.locknclimb.com
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Only an MRO provider with the most modern technologies delivers its customers the maximum benefit.

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Painting/Coatings

Link 1072

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Chemicals ▪ Cleaning ▪ Environmental Services/Green ▪ Military Maintenance ▪Painting/Coatings

Link 1026

MD TURBINES

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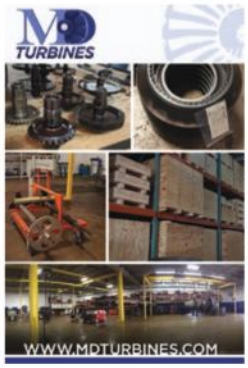
BOOTH 1629



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We specialize in the disassembly of CF6-6, CF6-50, CF6-80, CFM56, CF34, , PW2000, PW4000, JT8D-200, RB211 and V2500 engines. Quality and customer satisfaction are our primary goals to exceed the needs of our customers.

www.mdturbines.com

Engines

Link 354

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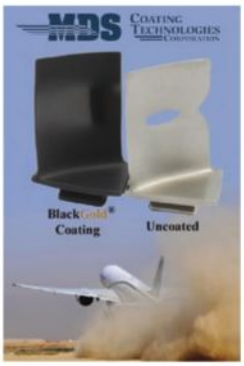

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Engines

Link 355

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Calibration/Weighing Services

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Chemicals ▪ Painting/Coatings

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Supply Chain/Logistics

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MTI Aviation Inc

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Painting/Coatings

Link 360

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Connectors/Fasteners

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Panasonic

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Cabin Interiors/InFlight Entertainment ▪ Parts Manufacturer ▪ Supply Chain/Logistics ▪ Third Party Maintenance

Panasonic.aero

Link 379

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Airframes ▪ Engines ▪ Landing Gear/Wheels/Brakes

Link 725

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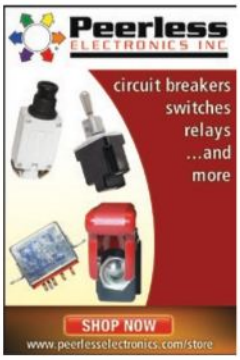

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Link 552

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Link 179

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Link 187

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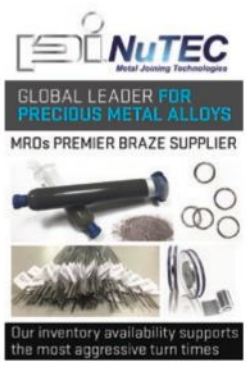

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www.ruag.com/aviation
Link 383

S3 REPAIR SERVICES LLC

S3 Repair Services - FAA #9S3R896B / EASA 145.6559

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Saint-Gobain: Aerospace Innovation

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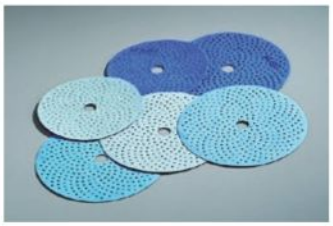

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Components ▪ Ground Support Equipment ▪ Landing Gear/Wheels/Brakes

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Airframes ▪ Engines

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Link 213

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Parts Distributors ▪ Third Party Maintenance

Link 310

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Link 1146

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Landing Gear/Wheels/Brakes

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Economic Development

Link 1147

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Economic Developement

Link 1148

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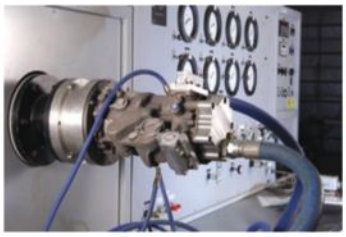

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Chinese Partners

Qantas, Air New Zealand look for allies to tap into booming market

An Air China flight departs Sydney, one of the Australasian cities where Chinese carriers are expanding services.

SYDNEY AIRPORT

Adrian Schofield Auckland

Traffic between China and Australasia is surging, thanks mainly to increased services by Chinese airlines. Carriers from Australia and New Zealand are attempting to exploit this market growth by forming alliances with their Chinese counterparts, but in the case of Qantas, its efforts are being rebuffed by regulators.

Qantas Airways and China Eastern Airlines want to establish a closer partnership on Australia-China routes, although Australia's main competition watchdog has signaled its intent to deny the proposal. Meanwhile, Air China and Air New Zealand have applied to create a joint venture on flights between the two countries.

The backdrop to these moves is the growing presence of the big three mainland Chinese airlines in the Australia/New Zealand market, as well as emerging competition from smaller Chinese carriers. Hong Kong-based Cathay Pacific has long been a major force on these routes, but its mainland rivals are quickly adding frequencies and destinations in Australia.

Traffic between Australia and

China has increased by an average of 13% annually over the past five years, according to Australia's International Air Services Commission (IASC). However, Australian airlines have not participated directly in this growth, the IASC notes. Qantas has not expanded beyond its daily Sydney-Shanghai service and has seen its share of China traffic almost halved over a four-year period, to 13.6% in 2013. Virgin Australia Airlines does not serve China with its own aircraft, instead relying on partner—and part-owner—Singapore Airlines.

A new bilateral air services agreement between the two countries was completed in January, and this has opened new opportunities for Chinese airlines. Air China has announced it will launch a Beijing-Melbourne route in June, and Xiamen Airlines plans to begin its first Australian service by the end of this year.

In New Zealand, China Southern Airlines has increased its Auckland-Guangzhou service to twice daily this year. China Eastern recently introduced a seasonal flight to Auckland and will make it a year-round service in September.

China Southern has been the main driver of Chinese traffic expansion in Australasia in recent years, according to the IASC. Now Air China and China Eastern are boosting services to the region and are looking to reduce the risk by partnering with local carriers.

For Qantas, the proposed partnership with China Eastern would allow it to tap into the burgeoning Chinese demand while still keeping a lid on international capacity. The carrier has argued that rejecting the partnership request will lead to the "increasing marginalization" of Qantas in the Australia-China market.

China Eastern and Qantas already code-share on some routes between the countries, but they need regulatory approval for their plan to coordinate on scheduling, pricing and network. The Australian Competition and Consumer Commission's (ACCC) interim decision to reject the application shows that while this market is growing quickly, the regulator is still concerned about maintaining competition, particularly on key routes.

Qantas operates a daily return flight from Sydney to Shanghai, on which China Eastern code-shares. China Eastern has daily service from Shanghai to Sydney and Melbourne, and seasonal service to Cairns, in the far north of Queensland. Although Qantas code-shares on the Melbourne-Shanghai route, it does not do so on China Eastern's flight between Shanghai and Sydney. The new proposal would cover all of these routes.

The applicants say China Eastern

Fuel Saver

Fuel saver could spin off real-time flight-planning tool

Guy Norris Seattle

A software-based analytics tool developed by Boeing to give operators insight into fuel-use trends and possible areas for improvement is identifying greater-than-expected savings, indicating the potential for more holistic tools capable of finding wider, previously untapped efficiency gains beyond fuel-burn reduction, says the company.

Introduced in 2014, the Boeing Fuel Dashboard analyzes information collected automatically from each aircraft's flight operational quality assurance/flight-data monitoring system, as well as additional data from loads sheets, flight plans and downlinked digital information broadcast by the aircraft communications addressing and reporting system (ACARS). "We are bringing it all together to get a picture of what really happened on a particular flight," says Ken Sain, managing director of Professional Services at Boeing Commercial Aviation Services.

The data are automatically downloaded for analysis or transmitted to a web portal via file transfer protocol (FTP) or email. The system then assesses the variation between the actual fuel-burn performance, as seen on each sector and phase of the flight, against the expected flight plan. The software uses the data going back over weeks, months and even years to build up a detailed series of operational trends.

The Dashboard "breaks down the variance into different phases of the flight and then into different initiatives within the different phases of flight," says Sain. "It then highlights, using a stoplight system, where the biggest opportunities are. It would then start to work through where I need to go to get results," he adds. Using the data, operators can identify trends and determine changes to improve performance through modifications to flight planning, dispatch or training. The system "knows what station and what gates have access to a working ground power unit, for instance, and then it takes the data to figure out if they used the auxiliary power unit and, if they did, how much fuel got burned at that particular station."

The Dashboard is now in use with 17 customers, which among them operate around 800 aircraft. Developed to be aircraft-agnostic, the system currently handles a range of 18 aircraft types from turboprops to Boeing 747s and Airbus A380s, and monitors a throughput of $10 billion in spending on fuel. "We have been surprised at the size of the opportunity," says Sain. When the Dashboard was first set up, Boeing expected total fuel-burn savings across the fleet of

BOEING

will boost frequencies on its existing routes if their partnership is approved. The deal also would spur the airlines to explore new direct services, such as from Brisbane and Perth to Shanghai. Qantas says its existing code-share arrangements with China Southern would be unaffected, and it would essentially have two mainland China gateways.

The ACCC concedes there are some potential public benefits in the proposed Qantas-China Eastern partnership but believes these would be outweighed by the detriments. It notes that the pair "are each other's closest competitor" on the Sydney-Shanghai route, with a combined share of 83% of direct traffic. Air China is the only other carrier flying nonstop between these cities, although it does not offer daily service.

Other airlines offer one-stop service between Sydney and Shanghai, notably Cathay Pacific, Singapore Airlines and China Southern. While Qantas says these carriers would provide competitive balance, the ACCC is skeptical, highlighting that the one-stop airlines account for only 12-15% of traffic between Sydney and Shanghai.

The ACCC will accept submissions before releasing a final decision in May or June. It is rare for the ACCC to change its interim ruling, but Qantas says it will work with the regulator to try to assuage its concerns.

Air New Zealand and Air China are also seeking an expanded partnership on flights between their countries. They are applying to revenue-share on routes from Shanghai and Beijing to Auckland, with the deal expected to begin as early as December, assuming regulatory approval. Air New Zealand has an existing daily Auckland-Shanghai service, and Air China will launch a daily Beijing-Auckland flight as part of the deal.

The proposed agreement between the two Star Alliance members was first signaled in November. They already code-share on the Air New Zealand Shanghai flight, which will be operated exclusively by Boeing 787-9s from late August. The Auckland flight will be Air China's only New Zealand service.

Air New Zealand previously operated a direct flight to Beijing but canceled it in 2012 in order to concentrate on its Shanghai gateway. It code-shares on Air China domestic flights from Shanghai to Beijing and other Chinese destinations.

Despite China being New Zealand's second-largest source of inbound travelers, it remains "a challenging market for us to operate in," Air New Zealand says. Working with a strong Chinese carrier is expected to help it benefit from the enormous demand potential.

1-3%. "But when we actually brought all the data into the tool, the actual identified savings across the first 14 customers by late last year was averaging 4.5% of opportunity, with a 95% confidence level between 3.5% and 5.5%," he adds.

The Dashboard also includes an unusual feature that allows pilots to see how the specific flights they operated compare to others on the same sector. "We can provide pilot-specific performance only to those pilots. The system sets up the names of the pilots into the tool and sends them a random password which not even the administrator knows," says Sain. "This allows them to log in and see exactly how they are performing on a particular segment across different initiatives like contingency fuel, single-engine taxi, reduced-flap landing and so on."

Data are shown on a curve, enabling each pilot to view his/her performance relative to peers and a marker indicating the value of a particular initiative. Sain says the system empowers crews because "it shows the pilots immediately if they change something, what it is worth. We haven't met a pilot yet who doesn't want to know this information, and be able to do it in a way that's secure and won't in some way be used to penalize someone."

Brazilian carrier GOL, a major operator of 737s, is among several airlines using Boeing's Dashboard system.

Encouraged by results from the Dashboard, Boeing is evaluating future evolutions of the system that could go beyond trend analysis and reduce the time to modify procedures and practices in almost real-time. "Longer-term, I think these solutions will be much more integrated with the entire flight-planning process," says Sain. "The major source of what you are measuring against is the flight plan itself, so there is no reason some of this could not be built into the front end of the system as well as the back end." In this case, trends would be analyzed, improvements identified and data passed directly back to pilots or loaders in real-time using tablets and other mobile devices developed by wholly owned subsidiary Jeppesen. "Mobile is a tremendous way to do that," adds Sain.

Future developments under study also include more holistic systems that could be used in other areas of an airline's operation, such as engineering and maintenance. "We see opportunities to expand that user base and provide a Dashboard for stations. We also see an opportunity to expand the focus beyond fuel," says Sain. Such a system, he adds, would compare actions across different domains that have an impact on overall cost efficiency. It would calculate, for example, the overall wear and tear maintenance cost savings of a derated takeoff, against the fuel savings of a regular takeoff. A derated takoff, although using a lower thrust setting, ultimately uses more fuel as the aircraft takes longer to climb to higher altitudes where engines are more fuel-efficient.

Fuel-cost reduction, and helping airlines deal with the volatility of fuel prices, remains the priority despite the decline in oil prices, says Sain. "Even with today's reduction in price, fuel is still the No. 1 cost category, and it will remain No. 1 even if fuel was to decline another 50%."

Catching a Cold

DUBAI AIRPORTS

Aggressive expansion by Emirates and other Gulf carriers may be a threat to international rivals, but for Airbus and Boeing, it is paramount to keeping widebody production lines flowing.

A CRT Capital study warns that parts of Boeing and Airbus backlogs might be under threat

Sean Broderick Washington

An analysis of the record backlogs at Airbus and Boeing suggests that U.S. carriers are the most likely to live up to their commitments, while the Middle East's major airlines could be significant order book disruptors if U.S.-led efforts to derail Gulf carrier expansion are successful, CRT Capital says.

CRT anticipates that the next five years of deliveries will take place largely as expected because they represent a healthy mix of both growth and replacement aircraft.

"We have conviction that Boeing and Airbus can successfully manage delivery positions of troubled carriers by swapping slots with their more prosperous peers," the CRT analysis states, adding that—as others have noted—Airbus and Boeing have likely booked orders for 10-15% more aircraft than they will ultimately build. Combined, the two manufacturers' reported backlogs totaled about 12,000 aircraft at the end of February, representing more than 85% of total air transport outstanding orders.

After 2020, when deliveries start to skew heavily toward fulfilling growth plans, the outlook is less certain.

"We do not believe that every order will survive the Darwinian struggle of

Regional Stakes

Finmeccanica strategy casts doubt on future of ATR, Superjet ventures

Jens Flottau Frankfurt and Tony Osborne London

As Finmeccanica continues its restructuring plans, the future of its joint ventures involving ATR and Superjet International are still on the table.

Finmeccanica CEO Mauro Moretti is grappling with the Italian group's debt in a bid to restore the company to profitability toward the end of this decade. He aims to refocus Finmeccanica on aerospace and defense after years of rapid expansion into areas out of its comfort zone, such as buses, trains and energy.

But in a broad stroke, Moretti has cast a shadow over the future of its two important regional-aircraft joint ventures, the ATR turboprop airliner program shared equally with Airbus, and Superjet International, established with Sukhoi to sell the Superjet 100 regional aircraft.

Since Moretti's arrival last May, the company has sold bus-maker BredaMenarinibus and will offload rail equipment-makers AnsaldoBreda and Ansaldo STS to Hitachi in the coming weeks. Moretti also wants to find a partner for its U.S.-based defense electronics business DRS, while a review of every business line will cut products and duplication between operating divisions.

As part of the restructuring, Moretti's strategy for joint ventures is two-fold: Either gain further control of them or consider other options, including selling the company's stake in them, particularly if they represent non-core activities. But this strategy poses particular challenges, as both ATR and Superjet sit firmly in the new Finmeccanica's purview of aerospace and defense.

Finmeccanica's views of the two businesses could not be more different, however. On the one hand, the company has a highly successful family of turboprop airliners, and on the other, a Russian-built regional jet that continues to struggle to make inroads into an already-saturated market.

For a number of years, ATR has seen very high demand for its aircraft because of their massive fuel efficiency advantage compared to small regional jets that are now no longer selling. The ATR aircraft are also dominating Bombardier's Q400 in their market segment. But the falling price of oil has decreased the ATR's operating cost advantage, which Moretti concedes made it difficult to decide which direction to take.

When he presented plans for Finmeccanica's restructuring in January, Moretti portrayed ATR's case in a good light, telling investors that ATR was a good business, enjoying a strong market position and bringing in good returns.

"We are realistic, and we will assess future investment plans of new aircraft against a realistic view of market demand in the future, not in the past," Moretti said.

He also points out that a key part of ATR's future will be the development of a new platform to replace the current ATRs, which first flew in the 1980s. It has long been sug-

survival of the fittest between the network airlines, Gulf carriers, Chinese airlines and ultra-low-cost carriers," CRT says. "We see the global competitive battle between airlines escalating over time. . . . There will be winners and losers, and aircraft orders will be casualties."

The North American carrier revival, strengthened by cost-streamlining consolidation and continued capacity discipline, makes the region's carriers the safest bets in the industry, CRT believes. "With North American airline credits improving, and financing plentiful and cheap, these customers are solid and predictable," the financial services company states.

The biggest threat to them—besides chasing market share by boosting capacity absent demand—is arguably the expansion of long-haul services by full-service carriers such as Emirates, Etihad Airways and Qatar Airways, as well as low-cost carriers with transatlantic aspirations like Norwegian Air International and Ryanair.

American Airlines, Delta Air Lines, United Airlines and several unions have formed an unusual and vocal alliance to challenge Gulf carrier growth—particularly long-haul services focused on routing passengers via hubs in Qatar and the United Arab Emirates, as opposed to serving the countries' origin-and-destination demand. European carriers have raised similar issues at home. The battle has captured much of the industry's attention, perhaps nowhere more than within senior executive offices at Airbus and Boeing, CRT suggests.

CRT calculates that the Middle East's four major carriers—Emirates, Etihad, Qatar and FlyDubai—hold nearly 7% of the total Airbus and Boeing backlog. The 800-odd orders are heavily tilted toward higher-priced widebodies, including 50% of the Boeing 777s on order and 60% of the Airbus A380s, making the commitments even more valuable than the straight order percentage suggests.

Although the Gulf airlines have dedicated backers in their governments, they still face headwinds that, if strong enough, could have a significant effect on aircraft delivery schedules. "The Gulf carriers face a rising protectionist effort in the U.S. and Europe, in particular," CRT notes. "The collapse in oil prices has removed billions from the Gulf economies. The airlines face revenue pressures from excess capacity, weak foreign currencies, slower economic growth and competition between themselves and network airlines throughout the world."

The issues facing the Gulf carriers are less acute than those challenging some big players in regions outside North America, CRT points out. European legacy carriers are caught between Gulf and Asian long-haul carriers on intercontinental routes and low-cost, traffic-generating machines such as Ryanair and EasyJet in their backyards. Asian carriers face the challenge of matching demand with expanding capacity as upstarts like AirAsia and Lion Air take on established incumbents.

But considering the stake that the big aircraft manufacturers have in the Gulf carriers' continued expansion, CRT says the Middle East's risks are just as significant as those of any region. If a Gulf carrier "sneezes" and does not follow through on its widebody commitments, CRT warns, "Boeing and Airbus would catch a cold."

Moretti says remaining in the ATR joint venture with Airbus would require significant investment to deliver a new platform to replace the now- aging ATR 42 and 72 (pictured).

TONY OSBORNE/AW&ST

gested that the development of a 90-seat turboprop could herald a new family of ATR models.

"For the development of a new-generation aircraft, it is necessary to deeply analyze the real market opportunities, taking into account the precariousness of the international macroeconomic scenario, mainly oil price and currencies," Moretti said in January.

Airbus and Finmeccanica have discussed the development of a 90-seat turboprop for years. Alenia has been pushing to proceed and even threatened to go it alone in 2012. But Airbus has vetoed the plan repeatedly, with CEO Fabrice Bregier last year stating that there was little point in progressing with a new aircraft while there was no competition in the market. Bregier also hinted that a new program was unlikely, given the inefficiencies in ATR's structure.

"We have to take care over our analysis; it is quite difficult to decide," Moretti told investors as Finmeccanica released its 2015 results on March 19.

"If we remain in the [joint venture] with Airbus, we may need to invest or innovate a lot, as the ATR platform is quite old," he said. "It is a double question, and a double problem that we have to study better [to avoid] mistakes."

Moretti seems less convinced about the future of Superjet International, however. The joint venture, formed by Alenia and Sukhoi Holdings in a bid to market the Russian-built Sukhoi Superjet in the West, has enjoyed limited success with sales in Mexico to Interjet and in Belgium to VLM. But Moretti says the company has yet to deliver a return on what he describes as "very significant investment."

"We are giving in-depth scrutiny to reassessing our position and reviewing the role and terms of our involvement," Moretti said of Superjet in January. Documents relating to the restructuring state that Superjet has suffered from ineffective governance and an inefficient industrial process, despite "encouraging and tangible results."

Moretti says Finmeccanica will not be pushed to make a decision on ATR or Superjet or indeed the other joint ventures under review. Any sell-offs would not be about reducing company debt or raising cash, Moretti told investors,

"We are not pressured into selling anything," he said.

Frightened Tigers

Revival in China's business aircraft sales depends on anti-corruption campaign

Bradley Perrett Beijing

Compared with most of the aerospace and aviation industry, business aviation is not very political. While other sub-sectors struggle with political influence even when a government is not the buyer, business jet makers mostly sell their products in deals too small to attract attention, a bit like the car industry. And their customers' use of the aircraft is, for the most part, a purely private matter.

Well, that is not true in China just now, where politics are front and center for business aviation. Probably the biggest question here for manufacturers is how long Beijing will maintain an anti-corruption drive that has frightened rich Chinese away from private flying. When showing off a jet is no longer asking to be investigated, the theory goes, the buyers will come back.

The campaign is also hitting industry through the Chinese economy, geared as it is to corrupt ways of doing things. That is undermining the confidence of potential buyers who are not fearful of investigation. But economics should have been a quite secondary factor in last year's decline in Chinese demand for business aircraft. Gross domestic product is, after all, still expanding at about 7% a year, so there should be a good deal more money available for buying private jets, not less.

Last year sales of business aircraft in China ran at about half of their 2013 rate, according to rough industry estimates, even though the experience of previous years suggested maybe 30% growth should have been expected. The industry reports only slight improvement this year, when sales might otherwise have been up around 70% on 2013. The campaign against misuse of public funds is affecting Chinese airlines, too: The great majority of officials are now forbidden from flying in business class, and economic lethargy is muting traffic growth generally.

President Xi Jinping and anti-graft enforcer Vice Premier Wang Qishan have given no hint that they will stop

REUTERS/LANDOV FILE PHOTO

The retirement date of Chinese Vice Premier Wang Qishan may be critical to business aircraft makers.

the hunt for so-called tigers and flies, big and little crooks in the government and business. At some point, however, the drive should at least moderate, if only to help the economy.

The campaign will stop in 2017, when Wang reaches retirement age, predicts Bo Zhiyue, director of the New Zealand Contemporary China Research Center in Wellington. While Wang is well known as the Politburo Standing Committee member running the campaign, Bo thinks the vice premier is personally the main driving force. His successor is unlikely to be so motivated.

One issue for Wang's successor will be damage to an economy that has enough other reasons to slow down, such as over-investment. That damage is appearing not only in the businesses that have benefited from corrupt activities and the spending of the dishonestly wealthy: fancy restaurants where connections are made and deals done; five-star hotels now off limits to state employees; luxury-goods shops formerly frequented by cashed-up officials and people buying gifts for them; and, yes, business aviation operators whose customers have been wantonly spending public funds or have earned their money shadily.

There is also the deeper economic problem that officials who used to be motivated to sign government contracts (they would get a kickback) now fear being investigated if they do. So they don't. Even the honest incentive of driving local development and thereby getting a promotion is no longer attractive to them, points out Bo, because a 2promotion comes with an investigation.

Though Bo notes that the government has ignored pleas to slow down its crook hunt for the sake of the economy, it may relent before 2017, says Ding Xueliang of the Hong Kong University of Science and Technology. But it would do so selectively, he adds; fewer people would be investigated in some industries and some regions. The government would not just drop the campaign. It is too large a part of Xi's contribution to China's progress. And specialists in Chinese politics agree on one thing: The campaign is highly popular. The Chinese people do not want it dropped.

For those reasons, Ding believes that even when Wang retires, the campaign will continue, but will be moderated. Importantly, Ding thinks much of the driving force behind the campaign is coming from Xi himself. It is not all about Wang.

Wang could continue in office after 2017 if allowed, despite the rules on retirement ages, as Ding thinks is possible. In that case, the best bet would be that the campaign would moderate more slowly than under a replacement. Wang conceivably could remain in office until 2022, when Xi is due to step down.

Whenever the anti-corruption campaign dies down, it will jump back to life maybe five years later, predicts Ding. Such drives come and go in China, though they have not been as fierce as the current one. Sooner or later, graft will demand renewed attention, because this campaign cannot deal with all of the enterprising officials eager for a chance to sell their power, nor all the business people eager to buy it.

The main motive for the crackdown is usually thought to be political: cleaning up the Communist Party to preserve its popular support. The effort could be over sooner, however, if the objective is mainly economic, as Kerry Brown of the University of Sydney believes.

Sprawling state enterprises have performed poorly in part because so

much money has been siphoned into private networks, Brown says. With economic growth now down from the 10% or more to which China has become accustomed, the national budget increasingly depends on those businesses performing better.

The campaign is not about to stop, Brown says. So far there is not enough pressure on Xi and Wang to back off. But once the state enterprises start delivering healthy profits, its main objective will be achieved. "There could be a very quick change," Brown adds.

Even if there were a quick change in the intensity of investigations, would there be a quick uptick in Chinese business aircraft sales? Maybe.

Already, the number of people inquiring about buying aircraft is back to pre-crackdown levels, even if they are not following through with orders, says Gulfstream. That suggests those wealthy people, who must be too busy to waste time looking at aircraft they never expect to own, are just waiting for a safe opportunity.

Bottom of the Bathtub

Chinese business jet demand may be improving, but just a little

Bradley Perrett Beijing

There are plenty of billionaires in China, but increasingly their business aircraft are not. Last year's trend to register private jets away from mainland China is continuing this year, say industry officials, reinforced by the growing habit of not seeking a local domicile for new aircraft.

These measures are probably helping the faint improvement in demand that some people in the industry are reporting for recent months. Still the companies that make business aircraft are dealing with a market that once presented an astounding opportunity but last year ran into the brick wall of China's anti-corruption crackdown.

Airbus figures for the number of billionaires in the growth markets of China, Russia and the Middle East well illustrate just how big that opportunity should be. By 2017, China should have almost as many billionaires as the U.S., Airbus says, relying on studies by Ledbury Research. At the same time, China has about 2% of the business aircraft that are registered in the U.S. Importantly, the number of China's billionaires has been multiplying much faster than for the Middle East and Russia. And the 2017 forecast number for China of 1,040 is 4-5 times higher than for the other two regions (see graph).

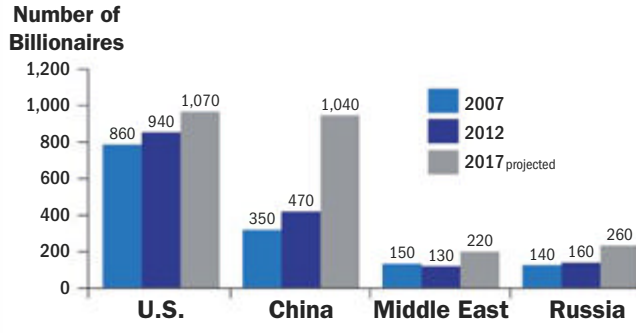
The billionaire threshold is particularly relevant, because for the sort of aircraft that are overwhelmingly chosen in China—big ones, generally costing tens of millions of dollars—buyers need to be worth more than hundreds of millions. But many of China's billionaires evidently have reasons to keep a low profile while the government of President Xi Jinping rounds up corrupt officials and the people with whom they have been completing deals. Economic growth has slowed, too.

Comparison with forecasts from before the Xi era illustrates the degree of disappointment for the airframe and engine manufacturers and their suppliers. In 2012, the consultancy McKinsey & Co. estimated the number of business aircraft in China would grow by 30% a year between 2011 and 2015. The forecast matched then-widespread optimism in the industry—and the figures did indeed turn out to be about right for 2012 and 2013.

But not for 2014. A steady fleet rise of 30% implies that deliveries also will grow by 30% from year to year, but in 2014 Chinese customers ordered maybe half as many aircraft as in 2013. (Exact figures are not available.)

And whereas McKinsey estimated in 2012 that annual fleet (and therefore delivery) growth would step up to 40% after 2015, there is barely a hint of anything like that right now.

Chinese business jet order numbers appear to be tracing the beginnings of a curve that looks like a bathtub: a sudden drop, followed by a very shallow rise and then, the industry must hope, a much stronger upward movement as normality returns. So far we have seen the drop and perhaps a little of the shallow rise. A big question is when the strong rise will begin, and it depends mostly on Chinese politics (see page 44).



Source: Ledbury Research via Airbus

The market appears to have recovered just a little, says Jeffrey Lowe of Asia Sky Group, a consultancy that watches fleet movements unusually closely. "We are starting to see the pendulum swing back, he says, emphasizing that the change has not been great. Buyers are subject to conflicting signals from Beijing, he adds. On the one hand, flaunting wealth just now is not wise. On the other, the government is encouraging companies to invest abroad. And long-range private aircraft are valuable tools for that activity.

"We are seeing a better environment," says Jean Michel Jacob, senior vice president at Dassault, without suggesting that anything like the good times are back. The Chinese market, having begun its rapid growth phase around 2008, is also now mature enough for some early aircraft to be candidates for replacement, he adds.

Gulfstream also has a mildly positive view of the market. "It is gradually coming back," says Roger Sperry, senior vice president at the U.S. company. But the biggest change is in inquiries, not orders. "We are in front of as many people as we were two years ago," says Sperry. "What we are finding is that it is taking them longer to make a decision."

Watching business aircraft activity in China means observing Hong Kong, Macau and Taiwan, too. Although the mainland is economically dominant, the people who are making

a lot of money there can register their aircraft nearby. They are increasingly doing so.

Formerly, aircraft were kept in such places as Hong Kong while the owners went through the lengthy process of applying for Civil Aviation Administration of China (CAAC) registration. That would allow the aircraft to fly in the mainland with fewer restrictions.

But last year it was noticed that aircraft were trickling back to Hong Kong, especially, at a rate of maybe two or three a month, while fewer buyers were applying for CAAC papers. The obvious reason was that owners had decided their aircraft were less likely to be noticed if they were not in mainland government records.

A change in tax rules has encouraged this process. Mainland taxes on importing the aircraft are high, so users set up leases with low payments. The tax authorities have closed the loophole by imposing a realistic deemed lease rate, and so now there is more reason to leave the aircraft outside of China, says Lowe. Taxes on parts also make owning mainland-registered aircraft expensive.

The CAAC's increasingly cooperative attitude toward foreign aircraft is another factor. It approves their flight plans about as quickly as it does for domestic aircraft, say industry officials. So the major remaining problem for a Chinese user of a foreign-registered aircraft is a requirement that it leave the mainland every so often. Since owners may well have need to make occasional flights abroad, that may not be as big an issue as it sounds.

For the manufacturers, it is just as well that owners and operating companies can keep aircraft off the mainland register, because the alternative may be to sell or not buy an aircraft.

Joint Successes

Textron and Caiga look to upgrade Cessna XLS+, Caravan partnerships

Molly McMillin Wichita

Three years after forming joint ventures for two aircraft in China, Textron Aviation officials say they are pleased with the progress as they work to expand capabilities.

In late 2012, Cessna Aircraft, now a division of Textron Aviation, forged separate joint aircraft completion ventures with China Aviation Industry General Aircraft Co. (Caiga). One was for Cessna Caravan turboprops in Shijiazhuang. The other, in Zhuhai, was for Citation XLS+ business jets.

"We feel like we've made a good decision," says Bill Schultz, Textron Aviation senior vice president for business development in China. "The partnerships gave us opportunities that wouldn't have been there if we had done this alone."

The Caravans and XLS jets are built in Wichita and flown to their respective sites in China, where they are painted and interiors are completed. Then they are delivered to customers inside the country.

The goal is to eventually perform all of the functions from final assembly to delivery at the sites. Those capabilities will be phased in as capabilities grow, Schultz explains.

The joint venture for the Caravan "stood up very quickly," he says. Deliveries began in late 2013.

Setting up the Citation XLS+ facility took longer, Schultz notes. Designing and building an elaborate paint booth took more than a year. The company delivered its first two XLS+ jets through the joint venture last year.

The turboprop market has been robust because of demand for special missions, Schultz adds. And the jet market continues to expand.

In 2014, the company delivered 11 Caravans and five business jets into China. Its installed fleet there comprises more than 50 jets and 80 turboprops.

Textron also operates a sales organization in Beijing and a business development headquarters in Shanghai. The company continues to develop customer support services and held its first operator conference last year.

Manufacturers want to be positioned in China, because it is such a large potential market, says Cai von Rumohr, an analyst at Cowen and Co.

China's aviation market is taking longer than expected to develop, he notes. And business jets are not the fad they were two years ago. "The airspace is still controlled by the military, and there is a push against an ostentatious show of wealth," von Rumohr says.

TEXTRON AVIATION PHOTOS

Cessna Aircraft Co. signed agreements in 2012 for two joint ventures with Caiga for Citation XLS+ business jets (left) and Caravan turboprops.

Textron Aviation has done well with the Caravan because of its utility, von Rumohr explains. And while the Citation XLS+ may be doing OK, "it's not a centerpiece for them."

In meetings with Textron Aviation officials, they said the Chinese market is not one of their first focal points. The focus is on the U.S., where the market is recovering, von Rumohr notes. Still, China adds business for Textron Aviation. "So that's all good."

Shedding Light

Exelis is working to enable UAS operations beyond line of sight

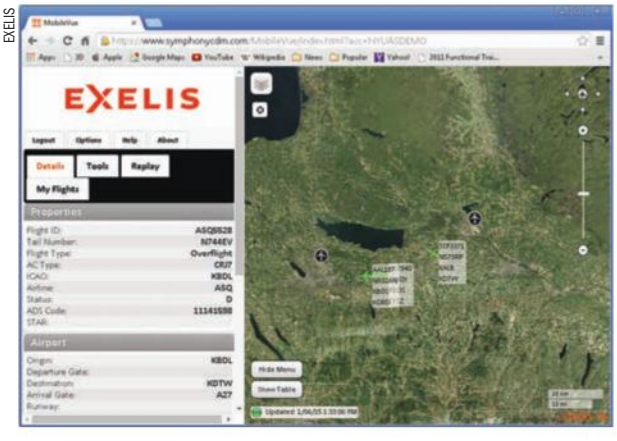
Graham Warwick Washington

Although the FAA is beginning to allow civil unmanned aircraft operations, they remain restricted to flying in daylight within visual line of sight of the pilot. But there is growing demand to fly beyond line of sight and some are concerned that the FAA will not act quickly enough to enable lucrative commercial operations.

But technology to overcome the challenges of operating beyond line of sight (BLOS) is beginning to become available, and Exelis is looking to exploit its position as operator of the FAA's Automatic Dependent Surveillance-Broadcast (ADS-B) ground network to enable expanded unmanned aircraft operations.

"Our main focus is on BLOS UAS [unmanned aircraft systems] operations," says Ed Sayadian, vice president of civil and aerospace systems. "The FAA's small UAS notice of proposed rulemaking defines criteria for commercial operations, but is fairly restricted—to VLOS [visual line of sight] of the pilot. It's a positive step, but there is still a lot of work to be done to get UAS to fly BLOS in bad visibility."

EXELIS



UASVue provides operators with a moving map of terrain and traffic and can run on a smartphone.

One core challenge, he says, is how to provide the operator on the ground with the equivalent of the pilot in the air's ability to see and avoid other aircraft. "One approach is to put sensors on the UAV to sense the environment and data link that down to the pilot. That requires sophisticated equipment, data-link bandwidth and sensors that can distinguish targets from ground clutter."

Another approach is to deploy a surveillance capability on the ground that looks up to see the UAS and their environment and provides that picture via ground network to the operators. "That is the approach we are investigating. It minimizes equipage on the UAV and works well with smaller vehicles without the size, weight and power capacity to carry sensors," Sayadian says.

"It works well at low altitudes, and alleviates the need for operator and equipment to be certified, shifting it to whomever provides the ground network," he says. Exelis's plan is to capitalize on the U.S. network of more than 650 ADS-B ground stations it operates for the FAA.

This system collects data from ADS-B, centralizes it and fuses it with data from primary and secondary radars, then distributes it as a managed service for the FAA. Exelis says of its joint rights to the data: "We will leverage the infrastructure to provide a situational awareness picture to any pilot on the ground."

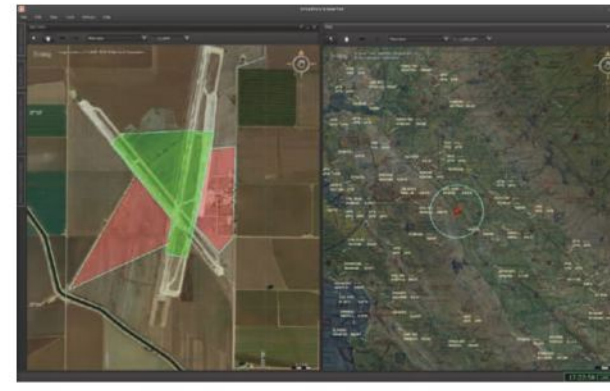
The service will begin using the infrastructure in place, but "as users come onboard, if we do not have the coverage required to service them, we will augment our coverage with ADS-B or radar sensors," Sayadian says.

"We can add surveillance sources as gap-fillers. If the UAS isn't ADS-B-equipped we can use primary radar. Or if the UAS provides the pilot with its position via a proprietary data link, we can interface with that to ingest data," he notes.

"[In many cases] we will have to do a coverage analysis and fill in gaps. With ADS-B, that is fairly easy and cost-effective. With a primary radar it is more difficult, so that's a primary area of research for us," says Sayadian.

"We will also provide a data-visualization tool, Symphony UAS-Vue, which is a moving map display showing where the UAV is relative to surrounding terrain and what is in the immediate airspace; alerting and alarming algorithms will warn the operator that a loss of separation is about to occur."

EXELIS



Designed for test sites, RangeVue shows UAS positions in real-time and collects and archives data.

Exelis is deploying the service to FAA-designated UAS test sites in Alaska, North Dakota, New York and Virginia to run trials and demonstrations. "We will develop the safety case and work with the FAA to get approval for BLOS operations," says Sayadian.

"We are targeting to run tests through the rest of this year and next, and to work with the FAA to develop the safety case toward the end of next year. We will understand it better as we get into it, as the environment evolves. Now there are a lot of unknowns, but we want to be proactive," he says.

Getting the solution out there in a test environment is important, "and then we'll start bringing it on and tailoring it as necessary," Sayadian says. "Then we can offer this as a service, alleviating the need for the operator to worry about sense-and-avoid." Operators will be able to concentrate on UAS and pilot certification and not be embroiled in ATM management, he notes.

Ground Power

NASA funds first manned distributed electric propulsion flight demonstrator

A truck-mounted testbed for the distributed electric propulsion wing has exceeded 80 mph on dry lakebed at Edwards AFB.

NASA PHOTOS

Wash from 18 propellers increases lift on the wing, and load distribution can be varied by controlling propeller speeds.

Graham Warwick Washington

NASA has begun high-speed testing of distributed electric propulsion by driving a truck-mounted wing with 18 propellers along a dry-lakebed runway at speeds exceeding 80 mph at Edwards AFB, California.

The novel Hybrid-Electric Integrated Systems Testbed (Heist) has been developed by NASA Armstrong Flight Research Center working with system integrator Empirical Systems Aerospace and Joby Aviation, which produced the 31-ft.-span carbon-fiber wing, electric motors and propellers.

Heist is a precursor to development of a small X-plane flight demonstrator under the Leading-Edge Asynchronous Propeller Technology (LEAPTech) program, one of the first projects under NASA's new Transformative Aeronautics Concepts program.

LEAPTech involves replacing the wing and engines on a Tecnam P2006T light aircraft with an improved version of the Heist wing and motors. One goal is to show that distributed electric propulsion will enable the aircraft to meet the FAA's 61-kt. stall requirement with a smaller, more-efficient wing. Using an existing light aircraft will allow direct comparison of performance before and after the modification.

The small propellers accelerate flow over the wing and increase dynamic pressure at the leading edge, more than doubling the maximum lift coefficient at low speed. This allows the large wing of a traditional light aircraft to be replaced with one that is one-third the size for lower cruise drag and has three times the wing loading for better ride quality. In an aircraft, the leading-edge props would fold at higher speed to reduce drag, and wingtip pusher propellers would provide propulsion.

"We are funded for three years to design, fabricate and test the Tecnam P2006T-based X-plane demonstrator," says Mark Moore, the NASA Langley Research Center aerospace engineer leading the LEAPTech project. "We've gone through the reviews and it is an approximately $15 million effort. We are working with several key technology partners who are conducting extensive cost-sharing."

LEAPTech will be the first manned distributed electric propulsion flight demonstrator, says Moore, and it is part of a NASA plan to develop elec-

tric propulsion technology for general aviation aircraft in the nearer term and hybrid-electric propulsion for transport aircraft in the longer term.

The Heist rig is designed to collect integrated lift-load data as the truck races down the runway. There are static and dynamic pressure sensors on one portion of the wing, accelerators, tufting and a top-mounted camera. "But the key data will be collected from the force balance at the base of the wing that provides full 6-degree-of-freedom forces and moments," says Moore.

The frame on which the wing is mounted floats on airbags in the truck bed to stabilize the wing and damp vibration to improve data collection on runs across the dry lakebed. Water ballast tanks mounted low on the truck keep the center of gravity of the floating system low, also for improved stability.

"The data is matching our computational fluid-dynamics predictions well so far, and with time-averaging we're able to get good-quality data," he says. "At 40 mph, the wing is achieving a coefficient of lift greater than 10 with 300-hp of power across the distributed propellers."

The speed of each motor can be controlled independently, which potentially could reduce noise through asynchronous operation, and planned tests include failing different motors and propellers to understand the change in stall behavior.

A modified P2006T-based X-plane will allow direct comparison of conventional and distributed-propulsion designs.

NASA CONCEPT

"One of the specific questions we are anxious to answer is what stall margin needs to be present for this type of highly coupled aeropropulsive wing, and whether we need to maintain a typical 1.3-times stall velocity margin," Moore says.

"We believe we will be able to show that safe operation will be achievable with significantly lower margins because at any time we can decrease the gust sensitivity with power effects extremely rapidly, and in whatever shape across the span loading that is desired for that flight condition."

Because of the low moment of inertia of the small propellers and high torque of the electric motors, thrust can be increased essentially instantaneously, in any spanwise distribution. "So for takeoff we may select a uniform elliptical distribution of thrust to match the elliptical span-loading for a highly efficient wing and minimum induced drag," he says.

"For landing approach, we may put more power into the outer span and less in the inner span to create a highly non-elliptical span-loading distribution to maximize induced drag," Moore says. "These types of tests are the intent of this rapid-test capability."

Space for Competition

Amy Butler Washington

Only a few months after Deborah Lee James took office as the 23rd Air Force secretary, Russia's bold annexation of Crimea last year sent the national security space community into a tailspin in the U.S. James, the Pentagon's executive agent for space, is now working to fend off restrictions from Congress on using the workhorse RD-180 engine for the Atlas V rocket while trying to create a competition between the United Launch Alliance—a government-funded monopoly—and commercial launch provider SpaceX. James talked with Senior Pentagon Editor Amy Butler in her Pentagon office about creating an apples-to-apples comparison of these dissimilar competitors, embracing public-private partnerships for a new rocket engine and developing trust with new launch entrants.

Deborah Lee James
Air Force Secretary

Age: 56

Career Experience:

President, Technical and Engineering Sector, Science Applications International Corp. (SAIC)

Several executive and senior vice president positions at SAIC

Executive vice president/COO at Business Executives for National Security

Vice President of International Operations and Marketing, United Technologies

Assistant Secretary of Defense for Reserve Affairs

Professional Staff Member, House Armed Services Committee

Education:

Bachelor of Arts, Duke University

Master's in International Affairs, Columbia University

AW&ST: Why won't an RD-180 replacement be ready by 2019 as Congress hopes?

James: The Mitchell study was one of the cornerstones of 2014, which I call the year of gathering facts and beginning to build a strategy. There is nothing worse than launching a brand-new government program, spending a lot of money and then ending up wasting it because you don't have that strategy.

My key takeaways were just how hard this science is. I was one who wondered: 'Can't we just essentially build an RD-180-like engine in the U.S.?' The answer is it is not that simple. This is very hard science. History teaches us that to build a new engine will take anywhere from 6-8 years. That is just for the engine. To do the integration [takes] anywhere from another year or two, and then we have our certification process. Even assuming we do better than history—that we can beat history—that still suggests to me that 2019 is extremely aggressive.

What kind of relief do you want to get from the law barring your access to future RD-180s for military missions?

I would welcome clarification on the intent of the language. [It was] designed to give us a sense of urgency to get off the reliance on the RD-180. Everybody is on board with that. We also wanted competition—two commercially viable domestic solutions so we can maintain our reach to space. There is where perhaps the law of unintended consequences has occurred. If I'm right and 2019 turns out to be too aggressive, then we could well face a gap [during the 2019-early 2020s] period. Simply trading one monopoly for another is one thing. But if we want the competition, then perhaps some change in that language ought to be looked at. You could make 2019 a different date. You could also change the language concerning the requirement to have fully paid for the engines by that date. We are trying to figure out the best way ahead. I imagine we will try to collaborate on this in the coming weeks.

You have investigated the possibility of dual-manifesting payloads to Delta IV if there is no relief from the RD-180 restriction. How much would this cost?

A Delta IV is about 50% more expensive than an Atlas V. We have funded some early studies about what the cost and time frames would be.

Are you OK with ULA retiring the Delta IV?

As a former business person, I can understand their perspective. As the executive agent for space, my job is to ensure we have access to space. So it is a conundrum, and the very thought of spending enormous amounts of money for the assured access to space is disturbing. We have to work our way through this with all the partners.

Given the conundrum, do you have levers to pull if the business interests of retiring Delta IV start to impede on your comfort level on assured access?

If the Air Force pays the amount required, I imagine that is the case. But that flies against what we are trying to do in all our acquisition programs. We are trying to drive all our acquisition program costs down. The thought that this one might go up is disturbing.

Moving forward post-lawsuit, can USAF and SpaceX have a productive relationship?

Absolutely. We already have, and I think it has gotten all the better. The recent press release we put out was a collaboration, and Mr. Musk has a quote in there.

With EELV, the government gave each team $500 million to develop designs; industry added funding. The program later got restructured. Some see this as a success, some do not. What is a reasonable public/private partnership moving forward?

A key difference between the approach we are going to be taking versus what happened with EELV is that [then] there was a belief—which turned out to be overblown—that there would be a very large commercial market. We are going

SCOTT ASH/U.S. AIR FORCE

to assume a much more modest commercial market. We are taking information from industry back to refine the public-private partnership approach. We have a four-point process. The tech maturation is already ongoing. We will start Phase 2 in a couple of months and fund several launch service providers to start on their engine alternatives [and one stipulation would be] the engines that they would produce would have to be made available for others. Next, once we have several of these viable alternatives, we would neck it down to one or two launch systems. The final step would be to award launches, and we would likely guarantee the winners a certain number of launches to help them make the business case.

Do you have a date for Phase 2?

The RFP will be going out within the next few months.

SpaceX claims ULA is the beneficiary of a "subsidy" and that the playing field needs to be leveled. Do you agree? If so, how?

In any kind of competition you have to—particularly [for] pricing—make sure you are looking at apples-to-apples data. In the past, when [it was just] ULA, the government funded ULA for this work in two buckets—one for the basic hardware, the other for the workforce and facilities. [It] made sense in that environment, but now there will be an apples-to-apples comparison.

When will that be ready?

It would be ready at the first competition, and we are hoping to have the first competition in fiscal '15.

Regarding the goal of an apples-to-apples cost comparison, how do you account for what personnel and infrastructure are government costs versus the very few commercial launches handled by ULA?

We are still working through those details.

How many competitive launches are you planning?

We are projecting two in '15, three in '16 and four in '17, for a total of nine.

What lessons have you learned

The Rise and Fall of a Launch Monopoly?

1986: Space Shuttle Challenger explodes, forcing the Pentagon and intelligence community to recommit to expendable launch vehicles.

NASA/KRT/NEWSCOM

1994: USAF crafts "assured access to space" policy, calls for two expendable launch vehicles with standard payload interfaces to provide redundancy.

1998: Initial EELV contracts awarded. Boeing wins 19; Lockheed Martin, nine.

2003: USAF suspends Boeing from competing for launches after proprietary Lockheed Martin Atlas V data was found to be in its possession illegally during the EELV competition. Boeing's EELV tally reduced to 12 from 19 and Lockheed's boosted to 14.

ULA

2005-06: As part of a settlement to the document scandal and to lower cost, Boeing and Lockheed form a 50/50 joint venture, the ULA, which sells and operates Atlas V, Delta IV and Delta II services to the U.S. government.

2006: AFRL awards Aerojet Rocketdyne hydrocarbon boost engine contract.

2012: Pentagon announces intent to allow new entrants into EELV competitions if they become certified.

July 2012: NASA awards Aerojet Rocketdyne contract for advanced Booster Engineering Demonstration and Risk Reduction for advanced kerosene engine, which is a precursor to AR1.

SPACEX

Oct. 28, 2012: SpaceX's Dragon capsule executes first successful mission, returning to Earth from the International Space Station.

Dec. 5, 2012: SpaceX awarded two EELV-class missions by USAF; delivery of the NASA Deep Space Climate Observatory and STP-2 satellites.

2013: USAF awards a $1 billion, sole-source deal to ULA for 36 rocket cores (28 missions) over five years and says it saves $4 billion compared to single-unit buys.

USAF/PATRICK CORKERY

Sept. 29, 2013: First Falcon 9v1.1 mission is executed, delivering the Cassiope satellite into orbit and validating the Merlin 1D "octaweb" configuration, although the second-stage refiring test—scheduled for geotransfer risk reduction—fails.

Dec. 3, 2013: SpaceX completes first Falcon 9 geostationary transfer mission with delivery of SES-8 satellite.

March 6, 2014: White House announces initial sanctions against specific individuals close to the Kremlin; they are toughened March 17.

from the first phase of the EELV certification study?

We have two very distinct cultures that have been operating in this environment—[SpaceX's and USAF's]. One is a culture of great innovation and speed and ours is a culture of history and experience, particularly when it comes to risk reduction and assured access to space. These two cultures have had some difficulty communicating. So even though the certification process is governed by a [cooperative research and development agreement] (CRDA)—it is all written down—you would think that would help people mutually understand what is expected. That was not always the case. There were some miscommunications. I think we were too focused, on the government side, on conducting detailed design reviews and instructing design changes as part of this certification process rather than focusing on the higher-level question: Do we trust this new entrant because of what they have actually demonstrated as well as what we have been shown in terms of their process or procedure? Do we have faith that they will be able to get to the actual launch? The detailed design review is quite appropriate as you get close to the final launch decision, but not as appropriate this early on. So this certification should be more about do we have confidence in their process, their procedures, what they've demonstrated to us, that they can get from here to there on time?

How then do you develop confidence, because the launch community—especially in USAF—lives and breathes in the weeds?

The CRDA is going to be amended to reflect what I have just described. The whole team will be instructed to try and lift it up to a higher level. Part of confidence is even if a contractor can't do every single thing right now, do they have a believable plan to get from here to there. If so, that is a confidence builder.

Must you amend this CRDA to reach the June certification date for Falcon 9 v1.1?

We are still projecting no later than June for SpaceX to get certified. Keep in mind they had already accomplished a good deal of what was required. There was a bit more to go. With the amendment of the CRDA—it is possible it could speed it up.

How does this affect future new entrants, be they Falcon Heavy or other designs?

Gen. (ret.) Larry Welch . . . is going to complete Phase 2, which will be taking a deeper dive. I'm hoping we come up with some other ideas to streamline while still providing mission assurance. That is expected later this year.

Extended Interview *To read more of James's views, including her thoughts on space control, tap here in the digital edition or go to:* **AviationWeek.com/James**

March 18, 2014: Russia annexes Crimea.

April 28, 2014: SpaceX files suit against the Air Force, arguing that the ULA contract was not properly competed and Russian RD-180 engine sourcing is unlawful in light of sanctions.

May 13, 2014: Russia announces it will halt RD-180 sales for U.S. military launches and end work on the ISS beyond 2020. Sales continue.

AEROJET ROCKETDYNE

June 2, 2014: Aerojet Rocketdyne acknowledges AR1 publicly for first time.

Sept. 17, 2014: ULA announces partnership with launch startup Blue Origin to develop the BE-4 as an RD-180 replacement.

Sept. 20, 2014: ULA/Aerojet Rocketdyne solidify agreement for AR1, which is to be a backup plan to the BE-4 for ULA's Next-Generation Launch System.

December 2014: SpaceX, USAF miss goal of certifying Falcon 9 for national security launches, suggest it will be achieved in mid-2015.

Dec. 19, 2014: Congress passed law limiting military use of RD-180 engines.

January 2015: USAF officials begin talking about shift in launch policy to allow for two launch providers—not two launch families owned by a single company.

USAF

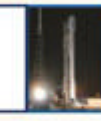
USAF

Jan. 14, 2015: Air Force Secretary Deborah Lee James announces review of new entrant certification process with a goal of streamlining it.

Jan. 23, 2015: SpaceX, USAF reach legal settlement. SpaceX drops lawsuit and USAF agrees to push more competitive launches, though detail is not made public.

Jan. 28, 2015: USAF awards ULA three sole-source missions, worth $382.9 million in total, to be completed by August 2017.

Feb. 15, 2015: SpaceX delivers DSCOVR satellite into orbit via Falcon 9 v1.1.



SPACEX

April 13, 2015: ULA/Blue Origin to unveil plans for Next-Generation Launch System.

2017: ULA/Blue Origin expect full-scale engine firings of BE-4.

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WHEN RESULTS MATTER

MILITARY SPACE

Range Savings

Deal reportedly could save $1.8 billion over 10 years

U.S. AIR FORCE PHOTOS

Telemetry equipment, FPQ-6 instrumentation radar and CT-4 directional antennas are part of the Western Range infrastructure housed at Pillar Point AFS, California.

Amy Butler Washington

Launch range operations are not nearly as spicy a subject as the rockets that depend on them. But they are an essential utility for the U.S.'s growing space ambitions, and the Air Force says it is embarking on a new path to manage the ranges that will save millions of dollars annually.

Detractors, however, warn that reduced cost for launch range operations will be a case of getting what you pay for.

Last November, a joint venture between Raytheon and General Dynamics—Range Generation Next (RGNext)—prevailed over five other competitors for a deal worth up to $1.8 billion over 10 years to consolidate three existing contracts for range support into one deal. Called the Launch and Test Range Integrated Support Contract (LISC), the transition to this new oversight went into effect April 6.

Command Transmitter 6 is housed on Laguna Peak at the Naval Air Warfare Center at Point Mugu, California, south of Vandenberg AFB.

Within the next 10 years, the Air Force plans to introduce all-new launch systems onto the ranges—the Falcon 9 v1.1, Falcon Heavy and, possibly, an Atlas V replacement. This work will underpin a new era of launch for the national security community under a deal that covers operations, maintenance and modernization.

Those legacy contracts covered activities at the Air Force's two launch facilities: Cape Canaveral AFS, Florida, and Vandenberg AFB, California. Incumbents included Raytheon and Computer Sciences Corp., ITT Exelis and InDyne.

By consolidating the contracts, the Air Force expects to save $95-115 million annually for range operations, says Col. Janet Grondin, chief of the Spacelift Range and Network division for the Space and Missile Systems Center, which oversees space procurement. Some of this will come from consolidated oversight, but Grondin also cited efficiencies to be gained through the new approach. She and Col. Keith Balts, who heads 30th Space Wing and the Western Range at Vandenberg, however, did not provide detail. "LISC is a more cost-effective range contract than the previous structure," Grondin says. "The contractor is on the hook to achieve the performance and . . . we have full confidence they will." The prior deals were a cost-plus structure, meaning contractors were reimbursed for costs incurred doing the work. LISC is a fixed-price incentive-fee structure, a mechanism selected to control cost.

Grondin referred questions on how RGNext will achieve the cost goals to the contractor.

"Part of the value we were able to bring to our bid included overhead consolidation, flat, integrated organizational structure, elimination of data silos, better information-sharing and situational awareness via smart, integrated information systems," says RGNext spokesman Jason Kello. "We also proposed better labor utilization via improved training and cross-utilization."

Operationally, however, "I don't see a whole lot of change on the day of launch," says Balts. That, however, is ultimately the goal; insuring a continued launch tempo, and performance is of paramount importance.

But detractors who have participated in range operations suggest that the savings goals are ambitious and essentially call for doing at least the same with less. The transition to LISC comes as the U.S. launch infrastructure has had two of its highest tempo years in decades. Grondin says the contract allows for flexibility based on the tempo; the challenge is that launches often cluster together and are rarely evenly spaced over time due to their required boost windows.

Meanwhile, the ranges are recovering from mandatory cuts from sequestration in 2013, which forced them to reduce usage of C-band radars for post-boost tracking; they are also used to support test launches for other agencies, such as the Navy.

Seven radars are used for tracking—four on the Eastern Range, three on the Western Range. Balts says one radar that was defunded for sequestration should be back up and running by the transition to LISC April 6.

The first launch under LISC is slated for April 10, with a SpaceX Falcon 9 performing a cargo resupply mission for the International Space Station. The manifest calls for the first Western Range LISC mission in June, when SpaceX lofts the Jason 3 ocean altimetry mission.

In parallel with the transition to LISC, officials have also introduced GPS tracking of Evolved Expendable

Launch Vehicles (EELVs) at the range. Previously, officials used the telemetry stream emitted from the rockets as well as radar tracking. These C-band radars paint the skin of the vehicles and interrogate them for specific data, Balts says. They will likely remain in use for this purpose despite the introduction of GPS tracking, although radar is no longer mandatory for EELV launches.

Balts says the Western Range conducted its first GPS tracking launch with an Atlas V lofting a National Reconnaissance Office payload last December.

New EELV program entrants—Falcon 9 v1.1 is expected to be certified for national security launches in June—must, however, be compatible with the ranges. Although SpaceX does not have to use GPS tracking for its current missions, the company will have to add the capability once it wins national security work for the Pentagon.

Moving forward, Grondin says, the Air Force plans to use LISC to upgrade the communications systems at both ranges and add new destruct capabilities, which are used if a rocket veers off course during launch.

Speed and Precision

Aerojet Rocketdyne pursues additive manufacturing with a focus on quality control

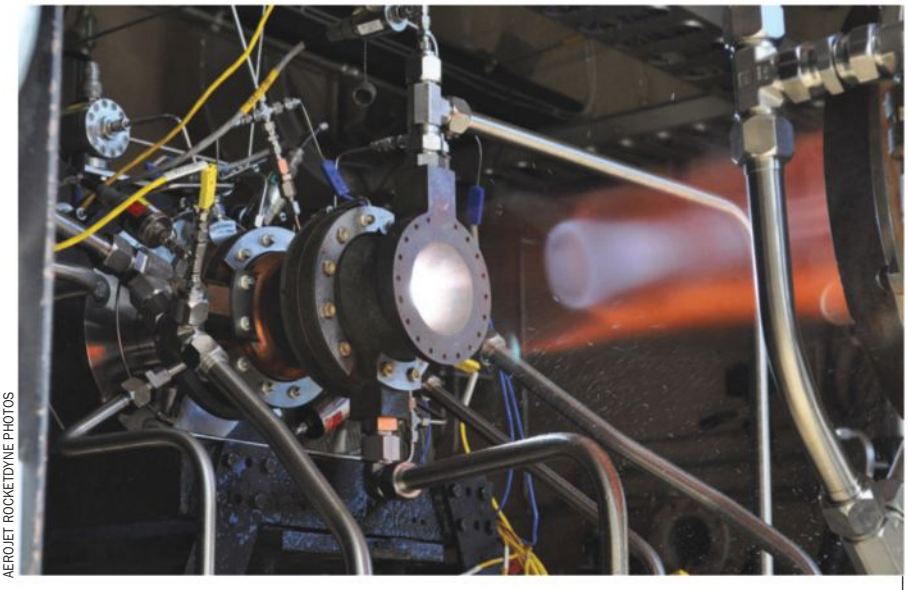
Amy Butler Washington

Additive manufacturing—or 3-D printing—is expected to help at least one competitor seeking to build the next $1 billion U.S. Air Force rocket engine to accelerate the design and production time.

But one company executive warns that a hasty rush to 3-D printing is dangerous. The process dramatically reduces cycle time to produce designs and parts. A fervent advocate of the technology, Jay Littles, director of advanced launch programs at Aerojet Rocketdyne, cautions that engineers should not cut corners in the validation process. "What scares me the most about these processes is [how] quickly you can go from something that is a [computer-aided design] that looks like a component, and can—if you have a machine—make 'something' that looks a whole lot like a component. But . . . the potential to not necessarily understand how the material that looks like Inconel 625 may not perform that way," is inherent, Littles says. "If rigorous material characterization and design system work is not done up front, it [has] the potential to . . . give the overall technology a bad name."

Aerojet Rocketdyne is not in an enviable slot; the company is the United Launch Alliance's backup plan if the Blue Origin BE-4 fails to progress as planned. But the company is working on producing its liquid oxygen/kerosene AR-1, capable of 500,000 lb. of thrust. And additive manufacturing will be a part of the program, building on years of work at the company to devise quality assurance for 3-D printing.

Several years ago, while still Pratt & Whitney Rocketdyne, the company



AEROJET ROCKETDYNE PHOTOS

Aerojet Rocketdyne conducts a test firing of a fully 3-D printed rocket engine.

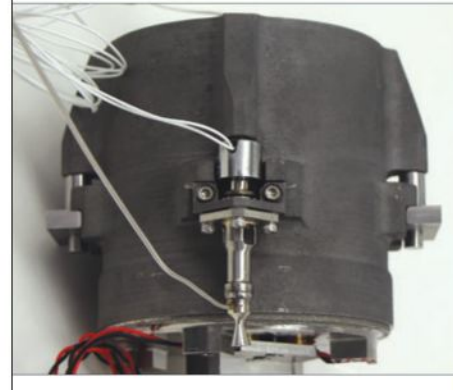
was struggling with what engine technology to invest in next. There was a general consensus that future endeavors must reduce touch labor costs, the price of piece parts and the cycle times to replace subsystems, Littles says. Thus the company embarked on a look at how to incorporate additive manufacturing, or 3-D printing, into its supply chain and processes. With additive manufacturing, parts are "printed" out of solid materials in printing chambers based on computer-aided design files; this reduces the number of parts requiring assembly by building up single-piece components. With traditional manufacturing, solid blocks of material such as titanium are progressively machined away to form parts; this process creates more waste.

For the past five years, however, the company has strived to solidify validation processes for 3-D printed parts to ensure they can be reliably produced and perform equally to traditionally manufactured parts, Littles says.

Aerojet Rocketdyne has two 3-D printers—one 10 in., the other 15 in. Littles says it is unclear yet what parts for AR1 will be developed with additive manufacturing. But the company has been aggressively pursuing 3-D printed equipment uses.

Design work on preburner injectors made with additive manufacturing parts is already underway, Littles says. Up to 75% of the design cost can be saved using additive manufacturing for AR1, and products can be produced 90% quicker, he adds.

Thus far, the company has conducted a full-scale single-element main injector hot-fire test, subscale preburner test and turbopump inducer test. The single-element main injector testing was done to assess designs with parts using different manufacturing techniques. Several injectors were fabricated using selective laser melting—a type of additive manufacturing. Aerojet Rocketdyne claims that tests in excess of 2,000 psi are the highest-pressure hot-fire tests of a 3-D printed part.



This CubeSat High-Impulse Adaptable Modular Propulsion System demonstration unit (above) was crafted with additive manufacturing. Aerojet Rocketdyne hopes to add maneuverability to propulsion systems for cubesats, shown (right) with an engineer for scale.

A vehicle-level system concept review and main propulsion system preliminary design review are planned for this year.

On a different project, a problem was detected with a part for a cubesat propulsion system. The CAD drawing was sent to the printer on a Friday; three days later, the replacement part was ready, allowing the program to proceed without delay, says Joe Cassady, executive director of the space division at Aerojet Rocketdyne. With traditional manufacturing, such an issue can doom a program.

Last year, Aerojet Rocketdyne hot-fire tested a demonstration engine composed entirely of 3-D printed parts. This particular powerplant—a derivative of the Bantam engine developed a decade ago for a NASA initiative to pursue a low-cost design—was made of three additive manufactured components versus the dozens of parts required when it is built with traditional processes.

The limiting factor in the part design was the size or "envelope" of the printer, which—at the time—was a 10-in. machine. Most 3-D metal printers melt powdered material laid down layer by layer to build up a design. Others use long wires of the material that are melted and deposited like a weld to form the part. Littles says advanced designs will allow for fabrication of larger parts in the future.

Aerojet Rocketdyne is now in talks with a potential, but unnamed partner to launch its 3-D printed cubesat propulsion system into space, says Cassady. The tiny engine—about the size of a French coffee press, has already been used as a test unit and was proofed to 9,000 psi, far beyond design requirements for cubesats, he says. The design has four thrusters—one on each corner. Depending on how they are cooperatively fired, operators can steer the cubesat.

But Cassaday says companies such as Planet Labs that are interested in deploying swarms of cubesats are looking for highly maneuverable systems, a requirement Aerojet Rocketdyne is working on.

Wider and Deeper

Astronomers studying Webb Telescope technology for larger deep-space observatories

Frank Morring, Jr. Washington

Astronomers hope that some of the techniques in development over the past two decades for the James Webb Space Telescope (JWST) can be reapplied later for even larger observatories able to produce unprecedented resolution of distant phenomena, including the birth of stars and the atmospheres of planets orbiting other stars.

While engineers struggle to meet a 2018 launch deadline for the 6.5-meter (21-ft.), $8.8 billion JWST, small groups of scientists are looking for ways to use the sophisticated technology in that infrared instrument to launch an aperture almost twice as large.

Sometimes referred to as a Large Ultraviolet Optical Infrared (Luvoir) telescope, the concept calls for a segmented mirror that could fit—folded into a tight cylinder—inside a large launch-vehicle fairing, as will the JWST mirror when it is launched on a European Ariane 5. In space, the primary mirror and the composite structure holding the secondary mirror that reflects photons into the observatory's instrument suite will unfold like an origami bird to create an aperture 10-12 meters across.

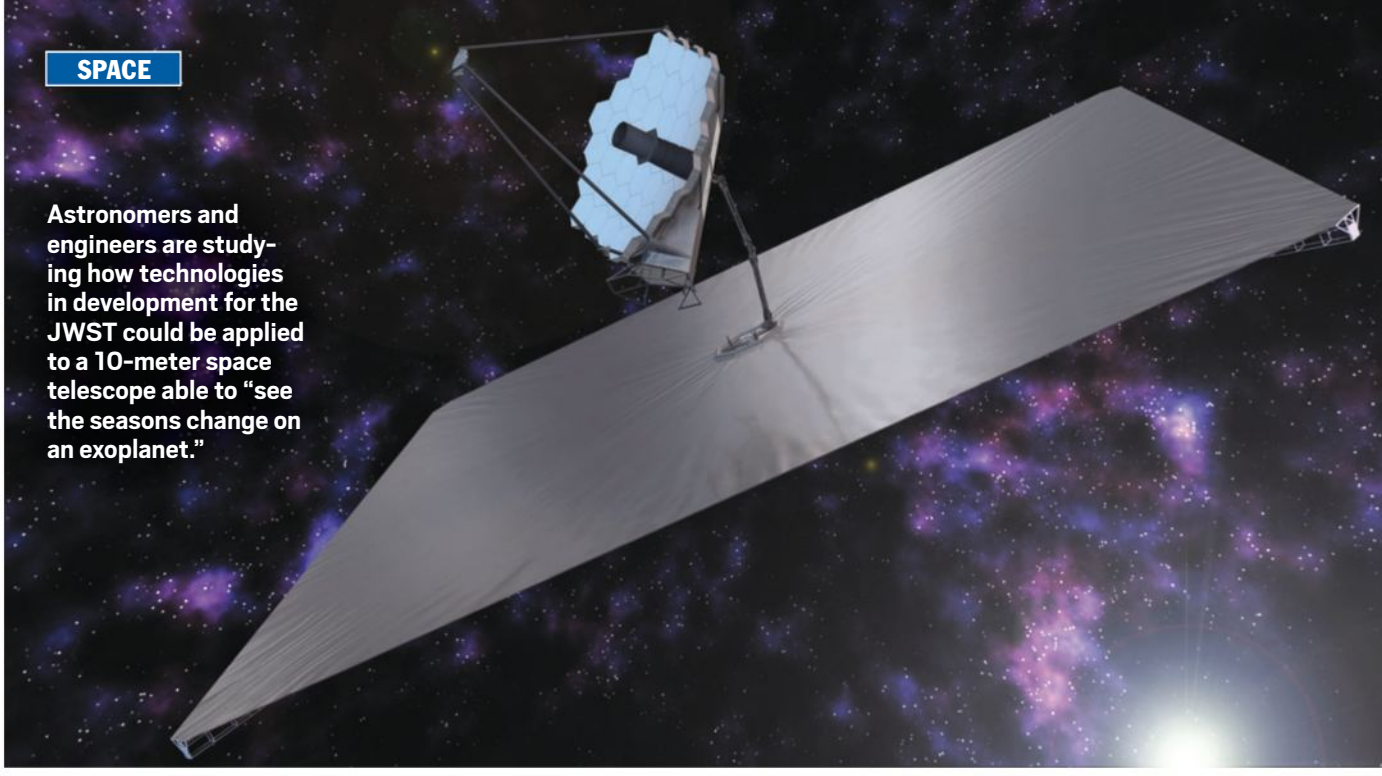
With a net that big to catch photons trickling in from the edges of time and the universe, astronomers hope to close in on the answers to some basic questions: "How does our universe work? How did we get here? Are we alone?" in the words of Kathy Flanagan, interim director of the Space Telescope Science Institute in Baltimore, which manages scientific research on the Hubble Space Telescope and will play the same role with the JWST.

"It would be able to detect biomarkers and evidence of life in other Earth-like worlds," Flanagan told the Goddard Memorial Symposium March 12. "Indeed, it is likely to be able to see the seasons change on an exoplanet."

Scientists expect the JWST to add to the observational data behind current computer simulations of what has happened since the universe was formed in the Big Bang, according to John Mather of NASA's Goddard Space Flight Center, the JWST senior project scientist and a 2006 Nobel laureate in physics for his work with the Cosmic Background Explorer spacecraft.

"That's why we build telescopes," Mather says. "We cannot do it by the computer."

Scientists believe only about 4% of the universe is visible to telescopes, and they fall back on the adjective "dark" to describe the invisible matter and energy that they infer drives the behavior of what they can see in the heavens. That requires wide-field views, and work is underway with a surplus 2.4-meter National Reconnaissance Office space mirror to de-



Astronomers and engineers are studying how technologies in development for the JWST could be applied to a 10-meter space telescope able to "see the seasons change on an exoplanet."

NASA GODDARD SPACE FLIGHT CENTER

velop the Wide-Field Infrared Survey Telescope (WFIRST).

As the name implies, WFIRST, will generate much wider field-of-view images for studying the expansion history of the universe, a key to understanding the mysterious dark energy that seems to be driving that expansion. It will also be equipped with a coronagraph to block the light from stars for direct imaging of the exoplanets orbiting them.

"The WFIRST, coronagraph will really provide the science and technical foundations for future missions that could search for life," says Mark Clampin, JWST observatory project scientist at the Goddard center.

That is where the Luvoir telescope comes in. With a 10-meter aperture, it should be possible to detect the spectroscopic signatures of life—ozone, oxygen, water, carbon dioxide, methane—in the atmospheres of exoplanets orbiting in the habitable zones of their stars, where water can exist in its liquid state, says Clampin.

The concept calls for "another order of magnitude" of contrast above that of the WFIRST, instrument, which is being designed to provide high-contrast imaging and spectroscopy of exoplanets. With that capability, the Luvoir observatory will be able to survey hundreds of stars, looking for the estimated 16% of exoplanets that lie in the habitable zone, and will be zeroing in to look for biosignatures.

"A 12-meter telescope also has a lot of appeal to the general astrophysics community," says Clampin. "One of the interesting things is, when you get to that size of aperture, you can basically resolve 100 parsecs anywhere in the universe, and that just happens to be the kind of scale of star formation in galaxies, so you can really start to study some of these other questions in great detail."

To do that work, the big future telescope would need to operate at room temperature, shielded from infrared radiation like the JWST by a multilayer sunshield. Deployment tests of that structure, which is the size of a tennis court, have gone well, Clampin says. The sunshield for a 10-12-meter telescope would be correspondingly larger (see illustration) and probably composed of three or four layers of lightweight insulating material.

To keep the telescope at a constant thermal profile when it moves to another target, it would be mounted on a gimbal instead of connected directly to the sunshield, as is the JWST. Present concepts call for the instruments to be serviceable by astronauts or robots. Clampin lists a number of JWST technologies and facilities that could be used to build a Luvoir instrument, including the Apollo-era thermal vacuum chamber at the Johnson Space Center where the JWST will soon be tested. Other examples of JWST technologies include a composite mirror backplane structure designed to hold its shape with great precision; wavefront-sensing and control to shape the mirror segments into a reflector with stability measured in picometers; the lightweight mirror segments themselves, with active thermal control for stability; and the various deployment mechanisms and latches that protect the telescope during launch and allow it to unfold in space.

"If you're going to try to do this, you really need to leverage what you already know," Clampin says. "We've spent a lot of time on JWST learning a lot of new technologies, building a lot of infrastructure that is now available."

Using that technology for new observatories in space has been the subject of a U.S. National Research Council decadal survey of scientists and will be addressed in a new report from the Association of Universities for Research in Astronomy now headed by Matt Mountain, who formerly ran the Space Telescope Science Institute.

The panel discussion that included Clampin, Mather and Flanagan was entitled "The Next Golden Age of Astronomy" by the American Astronautical Society, which organizes the annual Goddard Symposium. The panel's scientists were clear on the significance of the knowledge to be gained in that next era of astronomy.

"Active galactic nuclei turn on, liberating immense amounts of energy," said Mather, narrating an up-to-date simulation of the evolution of the universe that is sure to be modified by the work ahead. "Also, stars start to blow up, supernovae explode and material is enriched with the chemical elements of life. We are here because of that stuff. We wouldn't be here without dark matter, which is necessary to cause the galaxies to form. And we wouldn't be here without all those explosions that create the elements of life."

Back on Track

Korean Air bid to develop KF-X fails, KAI is preferred prime contractor

Bradley Perrett Beijing

As soon as South Korea's KF-X indigenous fighter was proposed last decade, the aerospace industry assumed that, if it were launched, Korea Aerospace Industries (KAI) would develop it and the type would follow a two-engine design of the defense ministry's technology agency.

Both assumptions have been challenged over the past two years. But now both are confirmed, though full-scale development is still not approved. The defense ministry has chosen KAI as preferred bidder for the program, rejecting a late and probably poorly developed offer from Korean Air Lines with backing from Airbus. And the joint chiefs of staff last year swatted down a KAI proposal to build a smaller, simpler and cheaper KF-X with one engine.

Airbus, meanwhile, may at least partly replace Lockheed Martin in the role of foreign technical supporter for the program, which is shaping up as the next big opportunity for Western suppliers of combat-aircraft equipment. The initial version of the type is supposed to use mostly foreign systems.

The ministry's Defense Acquisition Program Administration says it will now negotiate in detail for a program launch and final contract with KAI in the first half of this year. KAI was chosen after considering each bidder's development plan, ability and price, the purchasing office says. Until 2012 or later, the chief proponent of the program, the ministry's technology organization—the Agency for Defense Development (ADD)—planned to run the program as prime contractor. KAI would have been relegated to a role as airframe supplier, alongside the engine and systems companies. But ADD will not be allowed to take such a role, says a government official close to the project. The airframe developer and builder will be prime contractor, says the official.

Lockheed Martin is supposed to technically support KF-X development in return for South Korea's intended purchase of 40 F-35 Lightnings under the F-X Phase 3 fighter import program, which was decided in late 2013. But a key issue has been a South Korean desire to avoid a U.S. veto over foreign sales of the fighter and its integration with non-U.S. weapons, including indigenous equipment. That was a selling point of Korean Air's Airbus-backed proposal.

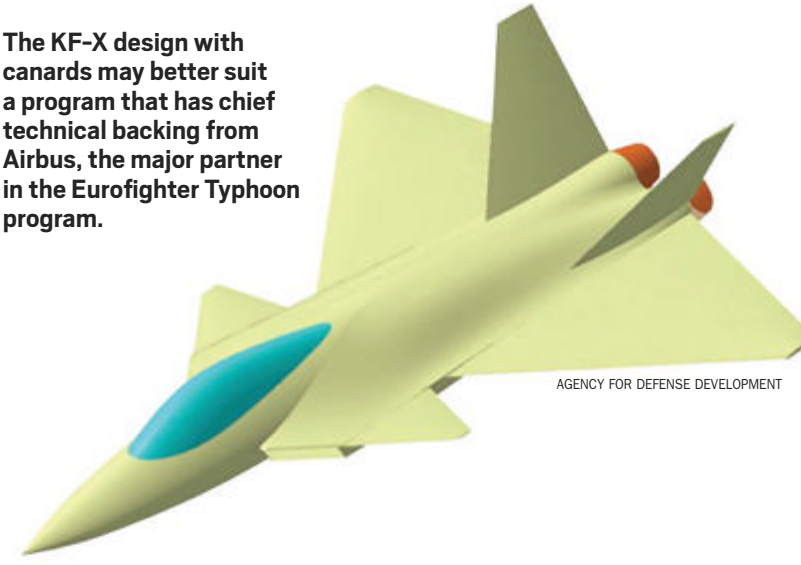
The risk of a U.S. embargo is a particular problem for KF-X partner Indonesia, which has agreed to pay 20% of program costs and take part in development. Indonesia was subject to a U.S. arms embargo as recently as the last decade for human rights violations.

Further, South Korean officials are concerned about U.S. reluctance to transfer advanced fighter technology, which will limit Lockheed Martin's potential contribution. So the U.S. company may get Airbus as a helper or replacement.

Now that South Korea has chosen KAI, the government can attempt to bring in one of the losing companies to solve the technology transfer issue, an unnamed government official tells the *Naeil* newspaper. Korean Air, which moved only late last year to prepare a bid, had a preliminary agreement for technical support from Airbus. Since Korean Air lacks KAI's skills in combat aircraft development, the official can only be referring to Airbus, part owner of Eurofighter.

If South Korea is determined to remove U.S. control over the KF-X's exports, then Eurojet—the consortium that builds the EJ200 engine of the Eurofighter Typhoon—should be well-placed in competition with General Electric, which can offer its F414 turbofan.

The finance ministry has approved the program, but funding is needed from the parliament—and from Indonesia. The contribution from Jakarta, revealed in memorandums of understanding signed with KAI and Korean Air, will be significantly lower than the intended 20%, says the *Segye* newspaper.



AGENCY FOR DEFENSE DEVELOPMENT

The KF-X design with canards may better suit a program that has chief technical backing from Airbus, the major partner in the Eurofighter Typhoon program.

Korean Air's bid for KF-X appeared to have some advantages, particularly insofar as the company, which has an aircraft manufacturing division but not a large engineering office, could economize by relying on Airbus technology and data. It missed the first deadline for bids but lodged an offer in time for the second and final deadline last month. The Korean Air concept design for the KF-X has never been revealed and cannot have been worked out in much detail.

Since the joint chiefs of staff said last July that a single-engine KF-X would not do, KAI has been committed to developing the two-engine design worked out over several years by the ADD. Or, rather, one of two ADD designs. The agency prepared one with a conventional tail plane, to suit a U.S. technical support company, such as Lockheed Martin, and one with horizontal stabilizers forward of the wing, to exploit European experience with that configuration. Both designs are about the size of the Typhoon, with an empty weight of about 11 metric tons (24,000 lb.).

Whatever Korean Air's motivation for preparing a bid in the last months before a contractor had to be chosen, the company's involvement must have suited the acquisition agency, since it created competition for KAI.

Beyond the Mirage

India's role in Dassault fighter upgrade could ease talks on Rafale sale

Caroline Bruneau Istres, France, and Amy Svitak Paris

As New Delhi seeks to strengthen its domestic defense industrial base, the role Indian companies are playing in the upgrade of aging Mirage 2000 combat jets could smooth Indo-French talks about a much more lucrative contract: the $10.2 billion sale of new Rafale fighters to the Indian air force.

Dassault Aviation delivered the first two of 49 upgraded Mirage 2000 fighters to the Indian military during a handover ceremony March 25 at the company's flight-test center in southern France. Under the terms of the €1.4 billion ($1.9 billion) contract, Hindustan Aeronautics Ltd. (HAL) will assume responsibility for modernizing the remaining Mirage aircraft in India. The industrial cooperation could help Dassault to finalize this year the sale of 126 Rafale combat jets to the Indian air force, ending more than three years of negotiations.

DASSAULT AVIATION

Arun Singh, India's ambassador to France, says the Mirage upgrade is emblematic of New Delhi's "Made in India" push to support local defense companies, including HAL, which is pressuring Dassault for a strong industrial partnership, including a French guarantee of Indian-produced Rafales—something Dassault is reluctant to do.

During the handover ceremony, Singh described the Mirage agreement as an opportunity to further solidify cooperation with Paris. "We look forward to French industrial participation in India's defense sector's extensive modernization plans," he said.

Eric Trappier, chairman and CEO of Dassault Aviation, agreed, adding that once the Rafale deal is finalized, the subsequent production ramp up would incorporate Indian companies already engaged on the Mirage 2000 retrofit.

"The 'Made in India' strategy has always been a driving factor for us," Trappier said. "We have established a close relationship with HAL—the major partner to the program—since they are upgrading the rest of the fleet in India and developing additional capabilities on their own for the Mirage 2000."

In addition to HAL, he said a group of Indian companies is also supporting the program.

Signed in July 2011, the Mirage modernization agreement kicked off a two-year development phase that saw Dassault and primary subcontractor Thales complete the maiden flight of the first updated jet in October 2013.

Although the Mirage contract originally covered the retrofit of 51 fighters, two have since been lost to accidents, according to Dassault.

Upgrade of the first two aircraft included a single-seat Mirage 2000 H KF107 and a two-seat mirage 2000 TH KT201. Retrofits to India's I/TI standard include a new multitarget RDY-3 radar, a new firing system for the MBDA air-to-air Mica missile and aircraft-to-missile links.

Other improvements include a five-display glass cockpit compatible with night-vision goggles, a new fully integrated electronic warfare countermeasures system (ICMS Mk. 4), new main-data-processing unit and an advanced identification friend or foe (IFF) system. Dassault also said French company Alkan produced and installed new pylons on both aircraft.

Dassault declined to specify when the Mirage upgrade will be complete but says the last retrofit kit will be delivered to the Indian air force in 2017. The upgrade adds at least 20 years to the aircraft's life. Given that 10 of the Indian Mirage jets are only 15 years old, they could be in service another decade before the entire fleet is modernized.

In addition to the €1.4 billion airframe agreement with Dassault and Thales, a separate contract of nearly €1 billion for 493 Mica missiles was signed with MBDA in January 2012. All the missiles are being produced in France, and MBDA declined to specify the period covered by the contract. But in general, missile deliveries occur when a first squadron, or even half a squadron, is operational with trained crews.

The MBDA upgrade will mean the Mirage 2000 can fire the Mica missile, which was previously not possible. The aircraft will be able to fire six missiles at six distinct targets, a considerable change from the former Magic 2 and Super 500-30D that used "paint-to-target" technology.

Hindustan Aeronautics Ltd. will upgrade 47 Mirage 2000 combat jets with help from Dassault, Thales and MBDA.

The Mica is a "fire-and-forget" weapon with an active radar seeker aid, offering a tremendous performance boost. This is in part why the retrofit is so expensive: The Mirage's entire electronics system has to be overhauled.

With the remaining 47 Mirage jets be modernized by HAL in India, where Thales employs 300 people, Thales and Dassault will send about 20 engineers to aid Indian contractors in the installation of the retrofit kit.

In the meantime, Trappier confirms that Rafale negotiations have been "95% finalized" with the Indian defense ministry. "I do hope we could go fast, but we would rather take time now than have problems later," he notes.

With Indian Prime Minister Naredra Modi slated for a trip to Paris this month, it remains to be seen whether his visit will be the end of the story for Rafale or a path to the future.

"We can't say," French Defense Minister Jean-Yves Le Drian says of the impending visit. "We cannot take too much risk when it relates to such a large contract."

Tipping Point

Test pilots find additional maneuver margin during aggressive F-35 envelope-expansion testing

Guy Norris and Amy Butler Edwards AFB, California

High angle-of-attack testing included intentional departures with weapons bay doors open.

U.S. AIR FORCE PHOTOS

The F-35 Joint Strike Fighter has been flown in air-to-air combat maneuvers against F-16s for the first time, and based on the results of these and earlier flight-envelope evaluations, test pilots say the aircraft can be cleared for greater agility as a growth option.

Although the F-35 is designed primarily for attack rather than air combat, U.S. Air Force and Lockheed Martin test pilots say the availability of potential margin for additional maneuverability is a testament to the aircraft's recently proven overall handling qualities and basic flying performance. "The door is open to provide a little more maneuverability," says Lockheed Martin F-35 site lead test pilot David "Doc" Nelson.

The operational maneuvers were flown by Nelson in AF-2, the primary Flight Sciences loads and flutter evaluation aircraft, and one of nine F-35s used by the Edwards AFB-based 412th Test Wing for developmental testing (DT). The F-35 Integrated Test Force at Edwards has six F-35As, two F-35Bs and a single F-35C dedicated to DT work, as well as a further set of aircraft allotted to the Joint Operational Test Team. Work is underway as part of efforts to clear the final system development and demonstration (SDD) maneuvering envelopes on the way to initial operational capability (IOC).

"When we did the first dogfight in January, they said, 'you have no limits,'" says Nelson. "It was loads monitoring, so they could tell if we ever broke something. It was a confidence builder for the rest of the fleet because there is no real difference structurally between AF-2 and the rest of the airplanes." AF-2 was the first F-35 to be flown to 9g+ and -3g, and to roll at design-load factor.

The operational maneuver tests were conducted to see "how it would look against an F-16 in the airspace," says Col. Rod "Trash" Cregier, F-35 program director. "It was an early look at any control laws that may need to be tweaked to enable it to fly better in future. You can definitely tweak it—that's the option."

"Pilots really like maneuverability, and the fact that the aircraft recovers so well from a departure allows us to say [to the designers of the flight control system laws], 'you don't have to clamp down so tight,'" says Nelson. Departure resistance was proven during high angle-of-attack (AOA) testing, which began in late 2012 with the aircraft pushing the nose to its production AOA limit of 50 deg. Subsequent AOA testing has pushed the aircraft beyond both the positive and negative maximum command limits, including intentionally putting the aircraft out of control in several configurations ranging from "clean" wings to tests with open weapons-bay doors. Testing eventually pushed the F-35 to a maximum of 110 deg. AOA.

An "aggressive and unique" approach has been taken to the high AOA, or "high alpha" testing, says Nelson. "Normally, test programs will inch up on max alpha, and on the F-22 it took us 3-4 months to get to max alpha. On this jet, we did it in four days. We put a spin chute on the back, which is normal for this sort of program, and then we put the airplane out of control and took our hands off the controls to see if it came back. We actually tweaked the flight control system with an onboard flight test aid to allow it to go out of control, because it wouldn't by itself. Then we drove the center of gravity back and made it the worst-case configuration on the outside with weapons bay doors and put the aircraft in a spin." The aircraft has been put into spins with yaw rates up to 60 deg./sec., equal to a complete turn every 6 sec. "That's pretty good. But we paddled off the flight-test aid and it recovered instantly," he says.

Following good recoveries from earlier high-alpha testing, F-35 evaluators are considering doing away with the spin chute for upcoming tests with asymmetric loads. The chute is pictured here during initial high angle-of-attack work.

Pilots also tested the ability of the F-35 to recover from a deep-stall in which it was pushed beyond the maximum AoA command limit by activating a manual pitch limiter (MPL) override similar to the alpha limiter in the F-16.

Following consistent recoveries, the test team opted to remove the spin chute for the rest of the test program. Although there are additional test points ahead where the spin chute is scheduled to be reattached for departure resistance with various weapons loads, the test team is considering running through the points without it.

With the full flight envelope now opened to an altitude of 50,000 ft., speeds of Mach 1.6/700 KCAS and loads of 9g, test pilots also say improvements to the flight control system have rendered the transonic roll-off (TRO) issue tactically irrelevant. Highlighted as a "program concern" in the Defense Department's Director of Operational Test and Evaluation (DOT&E) 2014 report, initial flight tests showed that all three F-35 variants experienced some form of wing drop in high-speed turns associated with asymmetrical movements of shock waves.

However, TRO "has evolved into a non-factor," says Nelson, who likens the effect to a momentary "tug" on one shoulder harness. "You have to pull high-g to even find it." The roll-off phenomena exhibits itself as "less than 10 deg./sec. for a fraction of a second. We have been looking for a task it affects and we can't find one."

Tipping Point

Test pilots find additional maneuver margin during aggressive F-35 envelope-expansion testing

Guy Norris and Amy Butler Edwards AFB, California

High angle-of-attack testing included intentional departures with weapons bay doors open.

U.S. AIR FORCE PHOTOS

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Small but Vital

Fastener redesign to determine how well new carrier's aircraft pass sortie test

Michael Fabey Washington

Whether the U.S. Navy keeps to the new schedule and cost estimates for the CVN 78 Gerald R. Ford aircraft carrier may depend on how well a set of redesigned fasteners for the ship's advanced arresting gear (AAG) survives a new round of crucial tests.

Fasteners may seem to be very small items for a $12.9 billion ship that carries its own airfield, but they anchor a system that ensures that most of the aircraft taking off from the vessel can land safely and quickly.

The ship is meant to generate 160 daily takeoffs and landings—aircraft sorties—by its own aircraft over a 12-hr. period, with a surge capability of 270 each day over 24 hr. The CVN 68 USS Nimitz-class carriers can handle 120-240, notes the Pentagon Director of Operational Test and Evaluation (DOT&E). But the Ford can reach those numbers only if the arresting gear performs correctly.

Indeed, those increased sorties are particularly important for the Ford, because its colossal price tag was justified by systems such as the AAG that were designed to increase its effectiveness.

Unfortunately, fasteners in the water-twisters—which the energy when arresting landing aircraft experience an unexpected level of torque—had to be redesigned.

The revamped AAG components were delivered recently to the Huntington Ingalls Industries Newport News Shipbuilding yard in Virginia, Rear Adm. Thomas Moore, the Navy carriers program executive officer, told reporters during a March 19 briefing. The plan is to install the hardware while testing is still underway in Lakehurst, New Jersey.

Navy shipbuilding program officials try to avoid concurrent testing and installation, especially of key systems. If something goes awry, the components may have to be ripped out, adding even more costs and potential delays.

But waiting for AAG testing to be completed could cause undesirable delays. "It's a risk I have to take," Moore says. "I have no choice."

The Navy began CVN-78 construction in 2008, and the ship was christened on Nov. 9, 2013. The schedule to deliver the ship has already slipped to March 2016 from September 2015. The crew is scheduled to move onboard in August, followed by a combat systems trial in November.

As of now, the Navy says, the Ford's design is 99% complete; 98% of the material needed to build it has been procured. The ship is 87.4% constructed and 37.5% of the overall shipboard testing has been completed.

The Navy reports better results with testing on the flip-side of sorties—the new Electromagnetic Aircraft Launch System (Emals). Emals shipboard evaluation started on schedule in August 2014. The catapults entered the testing cycle on Dec. 16, again on time. Eight of the 12 motor generators have been "energized," or powered up. Further testing of the Emals—firing deadloads off the ship—is scheduled to begin in June.

Now the Navy is gambling it can get back on track with AAG tests.

"The system will begin arresting certain aircraft on CVN 78 before completing land-based testing on other aircraft types, risking discovery of new issues after ship delivery," the Government Accountability Office (GAO) says. "Given the concurrency in testing critical technologies, ship testing and construction, CVN 78 risks further delays."

The redesigned water twisters and revamped testing schedule have led to additional changes.

"The Navy descoped the No. 4 AAG engine, reducing the total arresting gear engines on the ship, including the barricade, to three, and diverted the following equipment to Runway Arrested Landing Site in Lakehurst: the water twisters, electric motors, purchase cable drum assemblies and cable shock absorbers for the No. 4 arresting gear engine," DOT&E notes in its recent annual report on major Pentagon programs.

Testing has shown that AAG should be able to recover aircraft planned for the CVN 78 air wing, a key feature for a carrier that is meant to handle an assortment of aircraft for the next half-century, DOT&E points out.

But, DOT&E cautions, "AAG's reliability is uncertain. At the Lakehurst test site, 71 arrestments were conducted early in 2013, and nine chargeable failures occurred. The program office last provided reliability data in December 2013 and estimated that AAG had approximately 20 mean cycles between operational mission failures in the shipboard configuration, where a cycle represents the recovery of one aircraft."

Following these tests, DOT&E says, the Navy modified the system but has yet to score the AAG reliability. Based on expected reliability growth as of 2013, the failure rate was 248 times higher than should have been anticipated. The Navy hopes for better testing performance with the installation of the redesigned equipment.

The U.S. Navy hopes a redesign of the advanced arresting gear on the new Ford-class carrier will pass the test and help increase sortie rates compared to those of the USS Ronald Reagan and other Nimitz-class carriers.

MICHAEL FABEY/AW&ST

More To Come

Armed UAVs are possible for Australia, adding to a broad renewal of military aviation

Bradley Perrett Melbourne

By now, Australia is supposed to have almost run out of military aircraft requirements. The wave of competitions that began in the late 1990s is virtually over. Just about every type of aircraft in the Australia Defense Force (ADF) is new or has a chosen replacement, and the main unresolved competition is for basic flight training, including trainer aircraft.

But with the government aiming to raise defense spending to 2% of gross domestic product by the early 2020s from 1.6% three years ago, there may yet be room for a few more aircraft requirements. One that has bubbled to the surface has been combat UAVs for the Royal Australian Air Force (RAAF), while Northrop Grumman senses a chance of selling its MQ-8C Fire Scout unmanned surveillance helicopter to the Royal Australian Navy (RAN).

And there remains a prospect of top-up orders for types that are performing well in service, including the Boeing C-17 airlifter and Airbus KC-30 tanker-transports. The latter could form part of a proposed renewal of the executive transport squadron, which is also in the cards.

The prospect of continued combat operations in the Middle East is driving the contemplated order for armed pilotless aircraft, a move that is backed by one of the country's leading defense analysts. Even before making a decision, the government has sent air force personnel to the U.S. to learn to operate General Atomics MQ-9 Reapers.

If Australia will continue to work with the U.S. and other allies in combat operations in the Middle East, then it would make sense to turn up with its own armed UAVs, says Australian Strategic Policy Institute analyst Andrew Davies. "Something like a Reaper with a Hellfire missile is the obvious option for the time being," Davies says. "They're a weapon that's suited to the operations the ADF has been undertaking in the past decade and a half, against determined but relatively poorly equipped adversaries such as the Taliban in Afghanistan."

"By having their own armed drones, Australian forces would have the capability unilaterally to identify and strike targets," he says.

This is essentially the reasoning behind the proposal, says the director of unmanned aerial systems for the RAAF, Group Capt. Guy Adams. Speaking to Aviation Week at the Australian International Airshow at Avalon near Melbourne in February, Adams emphasized that no decision has been made.

About 600 members of the ADF are in the Middle East, assisting allies against the Islamic State in Iraq and Syria.

Although described as a cost-effective way of improving Australian understanding of operations of such aircraft, the country's decision to train personnel also amounts to preparing the RAAF to operate them itself. Six members of the RAAF are learning to be Reaper operators at Holloman AFB, New Mexico, while a communication systems engineer is training at Creech AFB, Nevada, says Darren Chester, the parliamentary secretary to the defense minister.

"It would be remiss of Australia not to continue to develop our knowledge of this technology to ensure we are able to gain the greatest benefit from unmanned aerial systems and the best protection for our troops on future operations," says Chester.

The armed UAV order is under consideration as part of a review of the force structure, including a defense white paper and a plan for future capabilities due to be published this year. Pending the completion of that process, Australia is generally not ordering new defense equipment. But the momentum for a Reaper order seems strong.

The chief of the RAAF, Air Marshall Geoff Brown, said last May that Australia would definitely procure armed pilotless aircraft. "I think the combination of a good [intelligence, surveillance and reconnaissance] platform that's weaponized is a pretty legitimate weapon system for Australia," he said then. Buying propeller-driven combat aircraft seemed at odds with the primary mission of the ADF, controlling the maritime approaches to the Australian continent. But it fits well with the operations that the Australian forces have actually been conducting for more than a decade in the Middle East.

Australia is increasingly able to assist allies while relying on them for less support. The purchase of C-17s and KC-30s over the past decade has given its forces greater ability to deploy without assistance, while the RAAF is now even able to contribute to allied airborne early warning and control, thanks to its operation of six Boeing E-7 Wedgetail radar aircraft.

There may be another benefit in acquiring armed UAVs. The RAAF is probably looking forward to the day when it operates the jet variety, so having an experienced squadron would be helpful in stepping up to the higher technology level. Moreover, once combat UAVs are established in service, they will become candidates

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for replacement, possibly in the late 2020s, bolstering arguments for pilotless jet strike aircraft.

One type of UAV, the Northrop Grumman MQ-4C Triton maritime surveillance aircraft, is virtually assured of an Australian order, probably next year, with up to seven likely to be taken into service. The Tritons and at least eight—possibly 12—Boeing P-8 Poseidons will replace 18 Lockheed Martin P-3C Orions that were modified to a local standard called AP-3C.

One or two of the Orions have reportedly been modified rather more, however: as electronic intelligence aircraft converted under the Peace Mate program in the 1990s. It is also possible that there are no dedicated electronic intelligence-gatherers in the fleet, but that special electronic support measures (ESM) equipment is available for fitting to any AP-3C as required.

Either way, there must be some plan to extend the capability beyond the life of the Orion. The RAAF began retiring AP-3Cs, which are increasingly difficult to maintain, in 2013. The last should be gone around 2019, says Group Capt. Roger McCutcheon, who is leading the RAAF's transition to the P-8.

Australia's keenness to keep a low profile in airborne signals intelligence is shown by the internal installation of antennas on the Peace Mates. At the cost of reducing the strength of collected signals, the configuration ensures that no one knows whether an RAAF Orion crew over the ocean is exercising its maritime capabilities or engaging in electronic snooping.

The Tritons will come with a standard ESM package. That system should have greater performance than was possible within the same limited space and power in the 1990s. But it is not clear whether it will have the same performance as the equipment in the Peace Mates, and even if it does, whether the RAAF will be satisfied in simply extending a 1990s-level capability. If more space and power are needed for more capability, then perhaps two or three of the P-8s will provide it. They would have the advantage of carrying on-board operators, too.

A remotely piloted aircraft with weapons and good sensors is "a pretty legitimate weapon system for Australia," says the air force chief. The General Atomics MQ-9 would fit the bill.

McCutcheon says Australia's P-8s will have the same ESM fit as the U.S. Navy's—but he would not be expected to give any hint of special equipment intended to replace the Peace Mate capability. Adams declined to comment on ESM at all.

Australia will decide early next year whether to order the extra four P-8s. An adviser to the government on defense policy thinks it very probably will order them.

An advantage of maritime aircraft undertaking the electronic intelligence role is that they have an excuse for flying far from Australia without landing anywhere. This makes transports, such as KC-30s, unlikely candidates for the function.

But Airbus is likely to receive an order for at least two more KC-30s from Australia, which now has five of the tanker-transports. Former Defense Minister David Johnston foreshadowed the top-up order last year, adding that one of the two could be fitted as a VIP transport. "When you get good service from a platform it prompts you to say, why don't you get some more?" Johnston said then.

The RAAF's KC-30s have airline-standard passenger decks, so they are already partial replacements for the two Boeing 737 BBJ and three Bombardier Challenger 604 business jets of No. 34 Sqdn., based at Canberra. If capable business jets such as Dassault 7Xs were also ordered, and the BBJs and 604s retired, then the RAAF could reduce the number of types in service by one, suggests Olivier Villa, senior vice president for civil aircraft at Dassault Aviation. A problem with that idea, however, is that the 737 is the basis of the Poseidon and Wedgetail, both of which will be in RAAF service for several decades, so eliminating the BBJ may save little.

Australia has begun the process of ordering its seventh and eighth C-17s. Though no contract has been announced, the purchase can be assumed. Johnston also raised the possibility of a ninth and tenth being acquired. While that decision will also be part of the defense review, the defense adviser believes that Australia is quite likely to order units 9 and 10. One reason would be simply to share wear and tear between more airframes and engines, thereby extending the life of a type for which no replacement will be available for several decades. If RAAF units 7 and 8 are counted as in the bag, Boeing has five C-17s left unsold.

Northrop Grumman has hopes that the Australian budget will stretch to adding the MQ-8C, a pilotless version of the Bell 407 helicopter, to RAN service. The U.S. Navy is using the surveillance aircraft alongside Sikorsky H-60s on destroyers and frigates; the same pilots and support crews operate it. The RAN, which has a strong inclination to adopt U.S. Navy equipment, is receiving 24 units of the latest version of the Sikorsky type, the MH-60R.

For the pilot training program, BAE Systems is offering the Beech T-6C, partnering with simulator supplier CAE. Lockheed Martin, Pilatus and Hawker Pacific have proposed the Pilatus PC-21 for the requirement.

During missions in Iraq, the RAAF's E-7A Wedgetail has been controlling in excess of 70 aircraft at any one time in support of Operation Okra.

WING CMDR. PAUL CARPENTER/COMMONWEALTH OF AUSTRALIA

Australian Ambitions

Modernization road map moving air force and navy toward a fifth-generation culture

Guy Norris Los Angeles

Deployed in short order last year to bolster international operations against Islamic State (IS) militants in Iraq and Syria, Australia's Air Task Group is a compact bellwether of an air force in transition.

Comprising six Royal Australian Air Force Boeing F/A-18F Super Hornets, a Boeing E-7A Wedgetail airborne early warning and control aircraft and an Airbus KC-30A multirole tanker transport, the force has been punching above its weight since self-deploying in September with the support of Boeing C-17s as part of Operation Okra. The F/A-18Fs have hit IS targets with guided weapons; the E-7A has provided control and tasking services to hundreds of coalition aircraft; and the tanker has supported multiple international force platforms, offloading more than 3.65 million lb. of fuel in January alone.

The fact that Australia was able to swiftly field and operate a highly capable and nimble operation such as Okra provides encouragement to Australian Defense Force (ADF) planners as they orchestrate the RAAF's ongoing modernization. With a raft of new, network-enabled, manned and unmanned aircraft types either entering or poised to enter service in the next five years, and older generations phasing out, the air force is transforming itself into one of the world's most modern fighting forces. "It is a pretty big transition time," says Air Commo. Michael Kitcher, director of general capability planning for the RAAF. "It is interesting to think that in 10 years' time the oldest aircraft in our air force will be a C-130J."

The arrival of the fifth-generation Lockheed Martin F-35A Joint Strike Fighter, along with the forthcoming debuts of the Boeing P-8 Poseidon maritime patrol aircraft and long-range Northrop Grumman MQ-4C Triton unmanned aerial system, will form the vanguard of this transition. The process, which started in 2006 with the arrival of the C-17 and continued with the introduction of the Wedgetail and F/A-18F in 2009 and 2010, respectively, is also pivotal to Australia's broader goals for a fully integrated, networked force structure.

"When the 'Classic' [F/A-18C/D] Hornet retires very early next decade, we will be one of the only forces in the world—if not the only one—that operates in air combat space with the 4.5-generation Super Hornet and fifth-generation platforms," Kitcher says. "We won't have multiple fourth-gen platforms to operate. That presents challenges, but it also presents opportunities, and we have to make sure these opportunities are harnessed and directed across the joint space, not just in air combat space."

The drive to maximize the combined potential of Australia's modernized air, ground and naval assets is enshrined in Plan Jericho, an Australian military effort led by the commander of the air force, Air Marshal Geoff Brown. Detailed at the recent Avalon air show, Jericho is designed to develop a fifth-generation culture in the defense force, which will build on the networking capability of the RAAF's aircraft in conjunction with the growth of the Royal Australian Navy's (RAN) modernized fleet of Hobart-class, Aegis-equipped air warfare destroyers and Canberra-class Landing Helicopter Dock (LHD) amphibious assault ships.

"The intent is a joint project to ensure we knit together all the capabilities we have across the maritime, land and air sectors to generate the maximum possible capable force and make sure they can all talk to each other real-time—not with the level they could do, but with the level that they should do," Kitcher says. "We need to work out the level of connectivity we require to generate the effect we want, and not just embark on a project to connect everything together. So that's part of what

Jericho is about. The JSF is a stimulator for something that all air forces will eventually wrestle with. Jericho is air force-led but it is absolutely joint."

The introduction of the RAN's air warfare destroyers and LHD ships will bring with them "great radar capabilities, connectivity and great weapons, so we will make sure we get Wedgetail involved, P-8 involved, Triton, JSF, Super Hornet and [Boeing EA-18G] Growler," Kitcher says. "Getting them all integrated into that joint space is key, from a maritime-battle, a littoral-battle and land-battle perspective."

Having acquired its fleet of Super Hornets as an interim measure to bridge a perceived gap between the retirement of the venerable F-111 and arrival of the delayed F-35A, the RAAF now envisions the aircraft playing a major role for longer than originally expected. "The Air Force is very happy with what has been a rapid and challenging acquisition, but the capability we get out of them is impressive," Kitcher says. "It is definitely a significant step forward from the 'classic' F-18, and it is a logical step forward on the road to the JSF.

"The Super Hornet was initially purchased with a short-term horizon, and it is fair to say as part of the [Air Combat Capability Transition Review] that occurred in 2013 there were decisions made by government to look at extending that life through to circa 2030," he explains. "The most logical path that has been suggested is that early next decade, defense will present options to the government that look at the future of the Super Hornet." As well as extending Super Hornet beyond 2030 or replacement by the F-35 ". . . there are other options by then that might make more sense, which could include unmanned combat air vehicles. It could be a raft of things," says Kitcher.

The F-35A is now on schedule to reach initial operational capability (IOC) by 2020. The first two RAAF aircraft were accepted in late 2014, and the first Australian F-35 pilot, Squadron Leader Andrew Jackson, a fighter combat instructor, completed his first flight at the international F-35 pilot school at Eglin AFB, Florida, on March 18.

Preparations for operating the F-35 in Australia are ramping up following government approval in late 2014 for development of a major new facility at RAAF Base Williamtown, New South Wales. "We will be basically establishing a JSF precinct on a greenfield site at Williamtown where we will base a training squadron and two operational squadrons as well as maintenance support and other associated facilities. The runway will be extended from 8,000 ft. to 10,000 ft., so a lot is going on there," Kitcher says. Another F-35 squadron will be based at RAAF Base Tindal in the Northern Territory. The first squadron, No. 3 Sqdn., will be declared fully operational in 2021. All 72 F-35As on order are expected to be in service by 2023.

With visible progress on the program and the first RAAF kangaroo in the roundel insignia on the side of the F-35, Kitcher is confident that the troubled development effort has turned a significant corner. "Undoubtedly, between now and then, there will be challenges, but there's nothing I've seen that would indicate to me anything other than solid logic . . . [that] our plan is realistic and we should achieve IOC on time in late 2020."

The introduction of the RAN's LHD Canberra-class ship meanwhile has sparked debate over whether Australia should acquire up to 28 of the F-35B short-takeoff-and-vertical-landing variant in addition to the conventional takeoff F-35As to which it is committed.

The government has asked the military for feedback about the F-35B. The military capabilities that the F-35B can perform from an LHD must be "accurately described," Kitcher says. The LHD is an amphibious ship and was not initially purchased as a mini aircraft carrier. "There is a big difference between operating an amphibious rotary-wing capability and a mini aircraft carrier, so it is up to the government to decide."

Commenting on reports that a potential Bell Boeing V-22 tiltrotor purchase could be in the mix, Kitcher says: "Capability has been mentioned. It seems to operate with significant capability, but again that's the not cheapest platform to operate. You don't have to be a rocket scientist to know that's an option, just like the F-35B model. The B model has got issues with weight that the A model does not, in addition to complexity and cost."

USAF SGT. MARLEAH ROBERTSON

The first RAAF student pilot to fly the F-35, Squadron Leader Andrew Jackson, completed his initial sortie at Eglin AFB, Florida, on March 18. In May, the second RAAF pilot is scheduled to start work at the international pilot training center at Luke AFB, Arizona, where the first two Australian F-35As are located.

The RAAF meanwhile is working closely with the U.S. Navy to help smooth the path for the debut of the P-8, EA-18G and Triton over the next five years. The first RAAF P-8 crews start training in the U.S. this year, with initial deliveries scheduled to begin in 2016. Australia has been working officially with the U.S. Navy on the effort since 2007, when it received "first-pass" approval for Phase 2 of the Australian defense department AIR 7000 requirement to replace the RAAF's AP-3C Orion maritime patrol aircraft. Australia subsequently became involved in development of the U.S. Navy's P-8A "Increment 2" antisubmarine-warfare and acoustic system standard that will form the basis for the initial RAAF configuration. The country is also involved in helping to define the follow-on Increment 3 standard.

Like the U.S. Navy, the RAAF is developing the P-8 to work in conjunction with the MQ-4A Triton for its long-duration maritime surveillance requirements. "We expect Triton to be introduced on the current timeline early in the 2020s, assuming the government agrees. So we will have the back broken on the P-8 transition by then, and the AIR 7000 transition team is totally focused on inducting the P-8 and Triton capability as complement-

Ones and Zeros

Australia's Boeing E-7 Wedgetails are working well, with system improvements coming

Bradley Perrett Melbourne

In 2006, Australia was so concerned about the Wedgetail airborne early warning and control program that it had to think of how to keep Boeing committed to delivering it. The contract had a fixed price, with damages for schedule misses that by then were apparent. But the defense department was not much interested in compensation. It was fixated on obtaining the capability.

Nine years later, it has it. The Royal Australian Air Force (RAAF) has given a glowing report on the performance of the Boeing E-7 Wedgetail and its Northrop Grumman Mesa radar over Iraq in the campaign to suppress Islamic State. Only a few minor issues now need to be resolved before declaring the six Wedgetails fully operational, probably in the middle of this year, says RAAF Wing Cmdr. Paul Carpenter.

The type, which became initially operational in 2012 after a development program that ran for 12 years, is already in line for upgrades, notably for the Mesa.

The RAAF says the Wedgetail is performing reliably in Iraq, where it shares the burden of battle-space management with Boeing E-3 Sentries. "We are very happy with the performance we are getting out of the radar and the systems," says Carpenter, who until late last year led the RAAF's Wedgetail unit, No. 2 Sqdn.

Air Vice Marshal Chris Deeble, then the head of the Wedgetail program, would have been delighted to hear those words in 2006, when he told Aviation Week that Australia would reserve some of its rights to compensation to keep Boeing motivated. "We cannot afford to get a lesser capability than we have specified," he said then.

ing each other," Kitcher explains. Australia has eight P-8s on firm order, plus commitments for a further four, and expects to place firm orders for up to seven MQ-4Cs.

Final assembly of the first RAAF Growler electronic-attack aircraft is also underway in St. Louis. The first three crews have been qualified following training with the U.S. Navy at NAS Whidbey Island, Washington. As part of preparations for operations of the 12 aircraft on order, the RAAF is seeking government approval to develop an electronic-warfare training capability at the Delamere Air Weapons Range, 220 mi. south of Darwin in the Northern Territory. "That's a large range with a variety of targets on it that you can drop all forms of high-explosive [HE] weapons on, as well as tactical targets for non-HE weapons. Apart from being as flat as a billiard table, it is a good-quality range and is close to Bradshaw, another decent range about 100 mi. to the west," Kitcher says.

Northrop Grumman has delivered the centerbody/aft fuselage for the first RAAF EA-18G to the Boeing final-assembly facility in St. Louis. The section, which was the 115th Growler subassembly completed at Northrop Grumman, is the first of 12 destined for Australia.

NORTHROP GRUMMAN

Aimed at gaining IOC in 2018, the RAAF's Growlers will come with the standard Northrop Grumman ALQ-99 jamming system, but this ultimately will be replaced by the Raytheon Next Generation Jammer (NGJ). "Our intent is to propose those options to the government and to stay in lockstep with the U.S. Navy on Growler. It has proved extremely successful in the Super Hornet space and as far as possible, we intend to maintain commonality across the F/A-18F and EA-18G. It is therefore logical to consider that defense will be preparing proposals in due course to look at replacing those ALQ-99s with NGJ," Kitcher says.

Development of the KC-30 air tanker also appears to be progressing well, despite early issues encountered with the aircraft's tail-mounted refueling boom. "We are planning to do JSF trials with the boom in August 2015. So after a very checkered start, it is starting to look positive now. There have been changes to the envelope, changes to the design, changes to software, and they are all going in the right direction," he adds. Boom tests in Australia are underway and first operational use in theater is expected by mid-year.

RAAF air crews have also started training on the Alenia Aermacchi C-27J tactical transport in Waco, Texas, following the transfer of the first two aircraft to the Australian registry. The first of 10 C-27Js will arrive in Australia around mid-year and be operated by No. 35 Sqdn. initially from RAAF Base Richmond near Sydney.

"It is a critical part of the way we intend to war fight" (*AW&ST* Nov. 20, 2006, p. 30).

That way of fighting, not quite spelled out, was and is based on massive collection and dissemination of information, by and between such systems as Wedgetail, the Jindalee over-the-horizon radar, manned and unmanned maritime surveillance and electronic intelligence aircraft and the Lockheed Martin F-35, not to mention data supplied by allies, especially the U.S. The campaign to thoroughly network the RAAF and its sibling services is now taking a step forward with Project Jericho, prompted by the planned arrival of the F-35 into service in 2020 (see page 66). Deeble is now running the Australian F-35 acquisition.

In the end, Australia did not get all of the capability that it originally specified. Some items were downgraded or deleted, but it seems that none of the changes greatly reduced the Wedgetail capability. Boeing added functions that Australia did not originally ask for—and is now pleased to have. First delivery, contracted in 2000 for 2006, did not occur until 2009. The gap understates the program delay, however, because an inordinate three years was then needed to make the aircraft initially operational.

Now the Wedgetail is about to be fully operational—but not finally operational. The latter status will probably be reached the day before it is retired, says Carpenter, because the type will always be subject to upgrades. Already, "we still have a huge shopping list of things that still need to go in there, . . . lots more features to work on."

Upgrades are easier now that signals processing in modern systems is changed by software, not necessarily by switching hardware. "There is an enormous amount of potential in that Mesa radar that is waiting to be unlocked by a whole bunch of ones and zeros," Carpenter told reporters at the Australian International Airshow at Avalon near Melbourne in February. There are clear paths to upgrading the radar, he adds, giving no details.

Turkey and South Korea also operate the E-7. Although the three countries' aircraft are not identical, they all feature the Mesa, the active, electronically scanned array of which is mounted on a dorsal fin on the fuselage of the E-7. The aircraft is based

Boeing added features to the E-7 Wedgetail that Australia did not originally request.

BOEING

on the high-gross-weight version of the Boeing 737-700 airliner.

Typically, the Wedgetail deployed to Iraq has flown missions lasting 13-16 hr., including 8-12 hr. on station. Inflight refueling, while previously practiced, has become routine.

"We wanted the E-7 Wedgetail to take the role of the E-3, not be second-rate, and that worked," says Carpenter. "We wanted to be plugged into the American system and not be a burden and in fact be an enhancing feature." Logistics was part of that; the Australians supported themselves.

The deployed Wedgetail began contributing sooner than expected, on its first mission over Iraq in October. On that occasion, the aircraft was supposed to work as an apprentice to a U.S. Air Force E-3 in the busy northern sector of the country, so the Australians could learn the ropes before going solo in the southern sector, where fewer allied aircraft needed to be controlled. But the E-3 was unserviceable. The Wedgetail crew was forced to take on the northern sector immediately, putting to use experience gained in an intensive exercise program before the deployment.

The RAAF has not previously operated airborne early warning and control aircraft. In Iraq, a particular new task for the Wedgetail crew was the busy and critical one of orchestrating tanking for the aircraft in the zone.

The Wedgetails have been operating in Iraq above 30,000 ft. but not at their ceiling, 41,000 ft. They stay above the tankers and tactical aircraft, while U-2s and RQ-4 Global Hawks fly above them. The electronic support measures suite has been used in Iraq, says Carpenter.

The RAAF and its suppliers appear to have supported the Wedgetail well in Iraq. "Every time we had to replace a component or do some work on it, we had the right people, we had the right parts and the procedures," says the wing commander.

A last-minute addition to the aircraft was Internet protocol (IP) chat, which had been due for installation years later but was rigged up in weeks. The system, running through the Iridium satellite phone system, was used to communicate with the combined air operations center on the ground, with command-and-control aircraft and UAV operators. "The Americans used IP chat extensively," notes Carpenter.

Before the Iraqi deployment, a Wedgetail took charge of movements in the search for Malaysia Airlines flight 370 off Western Australia last year. The order to deploy was received one afternoon and the aircraft left its base, RAAF Williamtown on the east coast, the next morning. Only five workstations had to be manned for that job—compared with all 10 in Iraq or for a big exercise—but the work included the challenge of coordinating Chinese, Japanese, South Korean, New Zealand, Malaysian, U.S. and Australian aircraft.

The aircraft is named after the wedgetail eagle, an Australian bird with unusually acute vision.

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Future Events

May 5-6—MRO Baltics, Budapest, Hungary.
June 17—Commercial Aerospace Manufacturing Briefing, Paris.
Oct. 13-15—MRO Europe, London.
Nov. 3-5—MRO Asia, Singapore.
Nov. 3-5—Aerospace Defense Chain, Scottsdale, Arizona.

Aerospace Calendar

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May 4—Association for Unmanned Vehicle Systems International's Unmanned Systems 2015. Georgia World Congress Center, Atlanta. See www.auvsi.org/events1/eventdescription/?CalendarEventKey=4b6a54a9-2072-463b-9398-67c2c462ec2e
May 6—American Institute of Aeronautics and Astronautics (AIAA) Aerospace Spotlight Awards Gala. Washington. See www.aiaa.org/gala2015
May 11-14—33rd Annual Space Power Workshop, Manhattan Beach (California) Marriott. See www.cvent.com/d/n4qbdc
May 26-29—Eighth Chaos Conference at Henri Poincare Institute, Paris. See www.cmsim.org
May 26-28—15th Annual Association of Old Crows' Electronic Warfare Europe, Stockholm. See www.eweurope.com/page.cfm/Action=Form/FormID=6/t=m
June 1-5—University of Kansas Aerospace Short Course Program. Overland Park, Kansas. Also **June 15-19** in Montreal. Plus **Sept. 14-25** in San Diego. And **Nov. 16-20** in Orlando, Florida. See www.aeroshortcourses.ku.edu
June 4—Aerospace Today . . . and Tomorrow—An Executive Symposium. Williamsburg, Virginia. See www.aiaa.org/ATT2015
June 22-26—AIAA Forum and Exposition. Dallas. See www.aiaa-aviation.org
June 27-29—AIAA Propulsion and Energy Forum and Exposition (Space 2015). Pasadena, California. See www.aiaa-space.org
Aug. 31-Sept. 2—Airports Council International Latin America-Caribbean World Annual General Assembly 2015. Panama City. See www.aci-waga2015.com

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Take the Long View On Civil Space

Forty years ago this summer, and 15 years before the end of the Cold War, a U.S. Apollo spacecraft carrying a crew of three astronauts docked in space with a Russian Soyuz carrying two cosmonauts. The mission was more of a geopolitical milestone than a technological one—its advertised purpose was to test the compatibility of U.S. and Soviet docking systems and the feasibility of an international space rescue. But the partnership laid an important cornerstone for cooperation between the two adversaries in human spaceflight.

Today, relations between Moscow and Washington are arguably worse than in 1975, as Russia menaces what remains of Ukraine along with other neighbors and as its air and naval forces engage in dangerous cat-and-mouse games with Western militaries and even civilian traffic. But almost lost in all the ensuing diplomatic protests and Twitter barbs is the reality that cooperation between NASA and Roscosmos, the Russian federal space agency, has been largely unaffected.

Soyuz vehicles still ferry crews to the International Space Station—a capability the U.S. lost with the retirement of the space shuttle in 2011 and will not regain until 2017 or 2018. In February, Russia became the first ISS partner to commit to extend its participation to 2024, bolstering NASA's efforts to keep the station going beyond 2020. And Administrator Charles Bolden says a recent meeting with his new Russian counterpart, Igor Komarov, was "invigorating" (see page 32).

Russia's revanchist annexation of Ukraine's Crimean Peninsula and its role in fomenting a Ukrainian civil war are abhorrent. Nonetheless, it is encouraging that important work in civil space has not become a casualty of the poisoned political climate. If NASA is to achieve its goal of leading a costly human mission to Mars in the 2030s, it will require more cooperation with the rest of the world, not less. Which brings us to China.

China has arrived as an economic powerhouse and spacefaring nation. Yet NASA is the only federal agency prohibited by the U.S. Congress from undertaking any bilateral activities with the Chinese. As this magazine has opined, the ban is shortsighted and should be lifted in a careful way

> "Now it's time to bring China into the civil-space fold."

that allows Beijing into the club of top-tier spacefaring nations without compromising sensitive military technologies. China is going to be a major player in space, with or without NASA. It is better for the U.S. to have some influence on how it enters the club.

Space is an arena in which we must look beyond near-term political disputes and focus on the benefits that could be achieved over the long haul. Washington and Moscow have done that, and space exploration and use are better for it. It is time to bring Beijing in from the cold, too.

Keep an Open Mind On Mental Health

The mental health of commercial pilots is front and center following the crash of Germanwings Flight 9525. From what is publicly known, First Officer Andreas Lubitz apparently locked the captain out of the cockpit and deliberately crashed the Airbus A320 into the Alps, killing 150 people (see page 34).

The same week, a JetBlue Airways flight stan-

> "Privacy may have to take a backseat to safety."

dards captain who had to be restrained after he ranted irrationally on a New York-to-Las Vegas flight, filed suit against the carrier. Clayton Osborn believes JetBlue should have recognized he was not himself when he missed a preflight meeting, would not answer his phone and arrived at the airport disheveled and disoriented. He says he had a seizure linked to a childhood head injury.

But it would be wrong to suggest the world of aviation is oblivious to pilots' mental health. Most airlines screen pilots' personalities and emotional status before hiring. Many have systems to anonymously raise concerns about colleagues. ICAO's Manual of Civil Aviation Medicine has detailed guidance related to psychiatric illness; mood, personality and behavior disorders; stress; sleep disorders; and alcohol and drug abuse and dependence.

What is more, it is not as if health care professionals have all this figured out. Much is diagnostic guesswork and trial-and-error treatment, punctuated by patients' sometimes unrelated ups and downs. Much depends on what the patient is willing to share about his or her mental and emotional state. There certainly is no blood test, brain scan or questionnaire that reliably predicts whether a patient will become violent.

We will withhold judgment on the cause of the Germanwings crash, much less whether Lubitz's mental illness was the root cause and certainly whether his employer could have done something to prevent the tragedy. We find more objectivity in accident investigators' reports than in prosecutors' statements.

However, rather than being defensive about crew mental health issues, as some have been in the wake of the Flight 9525 crash, aviation should be open to the possibility that some changes might be needed. There could be more transparency about what carriers do regarding mental health. Privacy may have to take a backseat to safety to allow the connecting of a pilot's medical records to the airman's medical examination process.

To be sure, incidents of a pilot's mental state leading to damage or disruption in flight are exceedingly rare. But aviation has achieved its enviable safety record not by dismissing remote possibilities of failure but by working systematically to eliminate risks wherever it can.

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