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Keeping Runways Safe

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Managing Risk, Predicting Maintenance

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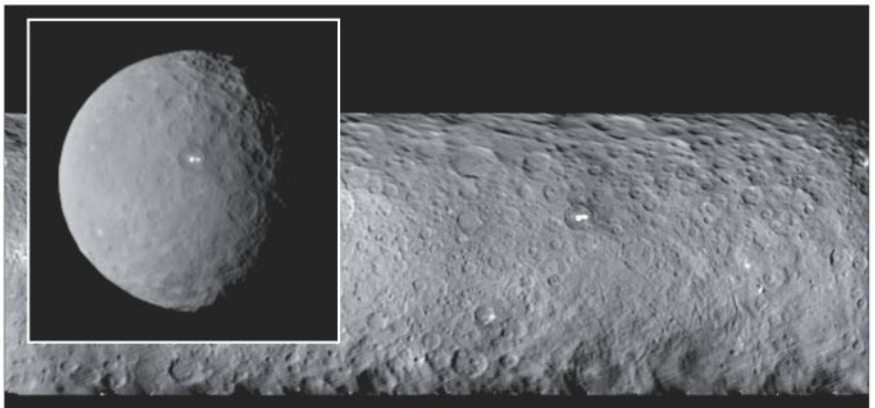

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This week, Aviation Week publishes two print editions. On the cover far left is an artist's concept of Eutelsat's Quantum satellite. The Airbus/Surrey Satellite Technology spacecraft will have a fully software-defined payload capability. That will allow its footprint and power to be changed from ground (see page 54). Elsewhere in both editions are reports on the new Airbus Helicopters H160 (page 44), Boeing 777 upgrades (page 26), counterstealth technology (page 49) and runway safety (page 64). On the cover of our MRO Edition, a Boeing 747-400 lands at Boston Logan International Airport. Photo by Kent Wien. Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*

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Feedback

NO SHORTAGE OF SHORTAGES

Regarding the pilot shortage. . . . No wait, the STEM (science, technology, engineering and math) shortage. . . . No wait, the shortage of medical professionals. . . and so forth.

H.L. Mencken stated it succinctly: "When someone says it's not about the money, it's about the money." A decent wage would cure a lot of the shortages.

I am speaking as a retired airline pilot who came from the military, where I received exemplary training. And I was fortunate to become a pilot for a major carrier at a time when one could do so and be well compensated.

Your recent articles about the pending pilot shortage (*AW&ST* Feb. 16-March 1, pp. 62-70) note it costs roughly $50,000 a year for four years at an aviation school to become marginally qualified for a regional airline position—which pays $20,000 per year.

Who can incur a $200,000 debt at the age of 21 and expect to pay it down on such a very low salary?

My daughter graduated from law school deep in debt, but her starting salary was well over $100,000 a year. She did the math.

US Airways Capt. (ret.) John Crocker
TAVERNIER, FLORIDA

CREATE PILOTS LOCALLY

John Croft's "Back to School" was well done (*AW&ST* Feb. 16-March 1, p. 68) but I would add that we need to lobby for regulations and incentives supporting the greatest numerical supplier of pilots—local airport flight schools that probably do not operate a fleet of sleek new Cessnas or Pipers, as does Embry-Riddle Aeronautical University—but whose efforts were just as important to the thousands of pilots who now are licensed to fly.

Perhaps we need to look back, reflect and return the favor to those who follow us by making the dream of being a pilot more accessible on a local level.

Robert J. Rendzio, President
Safety Research Corp. of America
DOTHAN, ALABAMA

SHORT TAKE ON SHORTAGES

No special programs are needed to avert the coming "Pilot Shortage." The law of supply and demand will correct the supposed problem.

Glenn A. Shaw
BELLEVILLE, MICHIGAN

NORWEGIAN REVISTED

Kudos for "On Autopilot" (*AW&ST* March 2-15, p. 41). The portrayal of pilots in the European Union who work for low-cost carriers (LCC) was further validated by the inclusion of surveys of these pilots, some of whom work without pay, under fixed-term, temporary contracts and pay-to-fly agreements.

Now that these ludicrous scenarios are in the forefront, can the U.S. and EU agree that allowing one of the most egregious abusers of these policies—Norwegian Air International—to fly to and from the U.S. with pilots who are based in non-EU countries is out of the question?

NORWEGIAN AIR SHUTTLE

I understand that these LCCs need to grow, but if you want pilots to fly your aircraft, pay them a decent wage and stop using temporary work agencies. All European pilots, especially those starting out at LCCs, deserve to be full-time, paid employees with benefits.

Bill Gist
OJAI, CALIFORNIA

MANDATE DETACHABLE FDRS

Your articles on the loss of Malaysia Airlines Flight 370 and the need for improved communications (*AW&ST* March 2-15, pp. 17 and 42-47) did not cover needed improvements to flight data recorders (FDR).

At the moment, an aircraft is required to carry one only FDR; and this is permanently attached to the fuselage structure. If the aircraft submerges, the wreckage can only be located by sonobuoys or hydrophones hearing the beacon transmitted by the FDR. This has proved to be very unsatisfactory and time-consuming.

Aircraft should be mandated to carry two FDRs, one of which is ejected when the aircraft hits the water; transmissions from this extra beacon can be heard not only by search aircraft but also by satellites.

Enhanced safety of course costs money, but the frequency of over-water flights is increasing and therefore the risk factors are too. Clearly, more needs to be done to enable the location of submerged aircraft in the event of such catastrophic accidents.

Tony Blackman
LONDON, ENGLAND

A-10 TAILOR-MADE FOR CAS

I'd like to applaud Amy Butler's "Domino Effect" (*AW&ST* March 2-15, p. 49) which covered the call to dispose of A-10s in light of the pending F-35's entry into service and to add an anecdote.

In 1970 I was working on the design of the A-X Aircraft Gun. The 30-mm. high-velocity GAU-8 (as it became designated) and its big magazine were fitted into what would become the A-10. This match-up rendered the aircraft near-perfect for close air support (CAS).

It was a formidable combination! Sending F-35s to attack insurgents would be comparable to delivering newspapers in a Lamborghini.

The notion of using the F-35 for ground attack sounds eerily reminiscent of the bright ideas from U.S. Defense Secretary Robert McNamara (who served in 1961-68) and his whiz kids, a consortium which knew the price of everything but the value of nothing.

Save us from the MBAs; listen to the people who actually do the fighting.

Leonard E. Capon
MESA, ARIZONA

VEERING FROM THE PATH

In 2004, when President George W. Bush and NASA Administrator Sean O'Keeffe announced the "Vision for Space Exploration," I was dubious. Why terminate the venerable shuttle?

Then in 2005 NASA Administrator Michael Griffin declared the shuttle "a mistake." I thought his desire for "Apollo on Steroids" was a folly.

When, in 2010, President Barack Obama announced the termination of the Constellation program, I hoped for better days and a continuation of the Space Transportation System (STS), including the venerable shuttle.

But then in 2012 NASA Administrator Charles Bolden, along with Sens. Kay Bailey Hutchison (R-Texas) and Bill Nelson (D-Fla.), announced the

Space Launch System (SLS) in the U.S. Capital rotunda. I again became disheartened.

Everyone should be interested in the space program, but as a NASA shuttle program development manager, now retired, I follow developments keenly.

When Obama and Bolden recently announced the Humans to Mars initiative, I knew our human space flight program was in disarray. We were destined to ride on the Russian Soyuz for years.

The shuttle was not and is not a mistake. We should return to the STS plan selected in 1972. The affordable path for program planning is via low Earth orbit, geostationary orbit, Lagrangian points 1/2 and the Moon. Mars is an overreach at this time.

Bob Thompson
HOUSTON, TEXAS

AIRMANSHIP AND STALLS

I feel compelled to add to reader Guy Wroble's excellent letter that clearly depicted the sad and dangerous state of airline pilot training (*AW&ST* Feb. 16-March 1, p. 8). I still remember that at the start of my lifelong interest in flying—initially as a humble glider pilot—my training underscored that an immediate, decisive push on the stick in an incipient stall is just the beginning of sequences needed to get out of the trouble.

In the Czechoslovak Aero Club's (late and lamented) training syllabus (both gliding and power) basic airmanship was always stressed as vital. Most of our light aircraft types were certified for at least entry-level aerobatics, while even the nonaerobatic models were usually certified for stalls and spins.

The current stall/spin avoidance training hogwash is actually an admission of the functional inferiority of a great many airplane types, both old and new. Many are merely an "aerial means of locomotion," not honest-to-goodness aircraft.

Martin Velek
PRAGUE, CZECH REPUBLIC

DUBAI AIRPORTS

READJUST THE FOCUS

"Accept Reality" and "Backing Up" (*AW&ST* Feb. 16-March 1, pp. 19 and 40) cogently outline attempts by the legacy airlines to restrict flying options for the Gulf carriers, and the pros and cons of options for the legacies.

But the focus is blurred; the criteria should not be what is best for these carriers, but what is best for the flying public.

Find the option that will provide comfortable seats, better services, faster connections, shorter flying times, more flying options, true competition and better value for the fares.

T. Nejat Veziroglu
CORAL GABLES, FLORIDA

USAF BEAT IXV BY DECADES

A recent item in the First Take section (*AW&ST* Feb. 16-March 1, p. 13) states that the successful flight of the IXV meant that "Europe was first to send a lifting body into space. . . ." You are wrong by nearly 50 years.

The U.S. Air Force SV-5D (X-23) Prime (Precision Recovery Including Maneuvering Entry) program successfully flew unmanned lifting bodies in space in 1966-67. The third vehicle was recovered after its flight and is housed at the Air Force Museum at Wright-Patterson AFB in Dayton, Ohio.

The even earlier Asset (Aerothermodynamic Elastic Structural Systems Environmental Tests) program flew lifting-body-like vehicles into space in 1961, although that design could be said to have had stubby wings, rather than being a pure lifting body like Prime.

I applaud the IXV program and am thrilled to see a program using actual flight tests to measure its design against the real world, but let's keep the proper "first" credit where it is due.

Marc McNaughton
ORANGE, CALIFORNIA
(The reader is correct—Ed.)


EUROPEAN SPACE AGENCY

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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.

Who's Where

James S. Turley

Philippe Gilbert

Thomas Keller

K. Pendergraph

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

Sandy Samuel has been appointed vice president/general manager of *Lockheed Martin Commercial Flight Training*, Orlando, Florida. She was vice president-operations for Lockheed Martin's Information Systems & Global Solutions and succeeds **Jeffrey Wood**, who will be moving to Lockheed Martin Aeronautics.

Paul Benson has been named vice president-human resources of the *Esterline Corp.*, Bellevue, Washington. He succeeds **Tom Heine**, who has retired. He was a senior human resources director at Hewlett-Packard.

Eileen Drake has become chief operating officer of *GenCorp Inc.*, Sacramento, California. She was president of Pratt & Whitney AeroPower's auxiliary power unit and small turbojet propulsion business. USAF Gen. (ret.) **Lance W. Lord** has joined the board of directors. He is chairman/CEO of L2 Aerospace. Lord was commander of Air Force Space Command at Peterson AFB, Colorado.

James S. Turley (see photo) has been appointed to the board of directors of the Falls Church, Virginia-based *Northrop Grumman Corp.* He is retired chairman/CEO of Ernst & Young.

Lynn Fenstermaker has been named project director for Nevada's *NASA Experimental Program to Stimulate Competitive Research and Space Grant Programs*. Fenstermaker is an associate research professor at Nevada's Desert Research Institute and its liaison for unmanned aircraft systems activities with Nevada-based UAS business interests and government entities.

Sylvain Laporte has become president of the *Canadian Space Agency*. He was the country's commissioner of patents/registrar of trademarks and had been executive director of the Industrial Technologies Office and chief informatics officer, both at Industry Canada.

Philippe Gilbert (see photo) has been appointed CEO-Americas of *DB Schenker*, Freeport, New York. He succeeds **Heiner Murmann**, who is retiring but remaining on the Schenker AG global board of management. Gilbert was director for Europe West.

Trevor Woods has been named certification director of the Brussels-based *European Aviation Safety Agency*. He succeeds **Norbert Lohl**, who has retired. Woods was flight standards director.

Robert J. Simmons has become CFO of SkyWest Airlines' and ExpressJet Airlines' holding company *SkyWest Inc.* **Wade Steel** has been named chief commercial officer. He was executive vice president and succeeds **Bradford R. Rich**, who has retired.

Linda Celestino has been appointed vice president-guest services for *Etihad Airways*. She succeeds **Aubrey Tiedt**, who is now chief customer officer at *Alitalia*. Celestino was general manager of inflight services and products at Oman Air and has been president of the New York-based Airline Passenger Experience Association.

Karl Fessenden has been named CEO of *CHC Helicopter* of Vancouver. He was an executive with GE Energy and GE Aviation and succeeds **William Amelio**, who has left the company.

Raj Mellacheruvu has become chief operating officer of the *Astrotech Corp.*, Austin, Texas. He was interim COO of Astrotech subsidiary 1st Detect.

Thomas Keller (see photo) has become general manager of the *Recaro Aircraft Seating* facility in Swiebodzin, Poland. He succeeds **Uwe Kothe**, who has retired. Keller was deputy general manager.

USAF Gen. **Robin Rand** has been appointed commander of the Air Force Global Strike Command, Barksdale AFB, Louisiana. He has been commander of the Air Education and Training Command, Joint Base San Antonio-Randolph, Texas.

Nicolas Robinson has been named Singapore-based Asia-Pacific director of product support sales for the *Gulfstream Aerospace Corp.* He was Johannesburg, South Africa-based sales manager for Africa and the Middle East.

Teresa Covington has become interim CFO for *AeroVironment Inc.*, Monrovia, California. She succeeds **Jikun Kim**, who has resigned as senior vice president/CFO. Covington held a similar post for the company's Efficient Energy Systems.

Dave McGrath has been appointed director of sales, marketing and business development for *VIH Aerospace*, Victoria, British Columbia.

Konrad Blocher has been named a strategic aviation analyst in the Dublin aviation finance office of London-based *Investec*. He was senior vice president-risk modeling at SMBC Aviation Capital.

HONORS AND ELECTIONS

Katherine Pendergraph (see photo), a project engineer in the Northrop Grumman Corp.'s Information Systems Sector, has been named an Asian-American Most Promising Engineer of the Year at the 14th annual *Asian-American Engineer of the Year Awards* ceremony. The awards recognize Asian-American professionals for leadership, technical achievements and public service in science, technology, engineering and mathematics (STEM). Pendergraph is a project engineer in Northrop Grumman's Information Systems sector, where she is responsible for verification and validation of development and operational software for a communications system. She has also supported missile and high-altitude, long-endurance aircraft programs. Two Lockheed Martin Corp. professionals also won awards at the ceremony: **Y.C. Yiu** and **Tina Lim** of Lockheed Martin Space Systems. Yiu received an Asian-American Engineer of the Year Award for his contributions to the success of many critical space systems. Lim received the Asian-American Most Promising Engineer Award for achievements in missile technology and commitment to enhancing STEM education for women.

James Trevelyan, sales director at Arqiva Satellite & Media, has been elected chairman of the board of directors of the New York-based *World Teleport Association*. He succeeds **M. Brett Belinsky**, managing director for Europe, the Middle East and Africa for Encompass Digital Media.

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Che Shanglun
President and Chairman
Xiamen Airlines

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First Take

AIRBUS HELICOPTERS

ROTORCRAFT

Airbus unveiled its H160 rotorcraft, a €1 billion ($1.06 billion) challenger to AgustaWestland's AW139, which has dominated the medium helicopter market for a decade. Formerly the X4, the H160 incorporates advanced technologies such as a carbon-fiber airframe and distinct composite blades with hockey-shaped tips to lower weight and improve fuel efficiency. Service entry is targeted for 2018 (page 44).

United Technologies Corp. (UTC) is considering a spinoff of its Sikorsky Helicopter unit as part of a drive by CEO Greg Hayes to improve shareholder returns. He has been looking at reshaping the company's portfolio of businesses since he was elevated to the top job last November following the abrupt departure of Louis Chenevert. Sikorsky had sales of $7.5 billion in 2014 but its profit margins were slimmer than UTC's two other main aerospace units, Pratt & Whitney and UTC Aerospace Systems.

Enstrom is launching the TH-180, a two-seat, piston-powered training helicopter that will sell for about $400,000 and is expected to be certified in the first quarter of 2016. The TH-180 is Enstrom's first new model in a decade and comes two years after the Michigan company was acquired by China's Chongqing Helicopter Investment Co.

COMMERCIAL AVIATION

Bombardier's CSeries test program has passed the halfway mark and is on pace to win certification by year-end. The company says the new jet family is meeting targets on fuel burn and range. The 135-seat CS300 made its first flight on Feb. 27 with a 4 hr., 58 min. flight from Mirabel, Quebec. It is slated to be certified after the 110-seat CS100, which made its first flight in September 2013. Both jets are expected to enter service in 2016 (page 37).

BOMBARDIER

Boeing plans to upgrade its 777 jet to keep the airliner competitive in the long-range market beyond the debut of the 777X derivative. A series of improvements in aerodynamics and other areas are aimed at boosting fuel efficiency by 2%. The company will also offer airlines the option of adding 14 more seats to boost the gain in per-seat fuel burn to 5% (page 26).

Emirates President Tim Clark says his carrier is prepared to order up to 200 A380neos if the reengined jet is launched, but Airbus remains cautious. "We obviously aren't going to build an airplane for one airline, even if it does buy a lot of them," says chief salesman John Leahy. Meanwhile, Air Lease Corp. Chairman and CEO Steven Udvar-Hazy says that if Airbus updates the A380 it should stretch the aircraft to add much-needed belly capacity and boost its appeal in the cargo market.

Senior executives at Airbus and Boeing defended plans to raise jetliner production rates and dismissed talk of an order bubble (page 28).

United Airlines issued a warning to its pilots to adhere to procedures and take safety seriously (page 34).

SPACE

After six months aboard the International Space Station, NASA's Barry "Butch" Wilmore and Alexander Samokutyaev and Elena Serova of the Russian federal space agency, Roscosmos, return to Earth in a Soyuz TMA-14M spacecraft. On deck to replace them are astronaut Scott Kelly and cosmonaut Mikhail Kornienko. They are scheduled to lift off on March 27.

NASA's Dawn spacecraft has arrived at Ceres, a dwarf planet in the asteroid belt between Mars and Jupiter and the largest unexplored world of the inner Solar System (page 29).

WIKIMEDIA

NASA Administrator Charles Bolden told a congressional panel that the agency would be forced to abandon the International Space Station if Russia stops flying U.S. crews to the orbital outpost on Soyuz vehicles. But Bolden believes such a scenario is unlikely. Boeing and SpaceX are developing vehicles to begin delivering crews to the station by the end of 2017.

Big gains are on the horizon for optical satellite communications, with new spacecraft demonstrating the potential of laser communications links (page 59 and AviationWeek.com/SpaceLaserRelay).

A Lockheed Martin-led team is aiming to parlay a modular space utility vehicle proposed for the second round of NASA's Commercial Resupply Services (CRS) space station cargo contract into a human-spaceflight services business ranging from low-Earth orbit to Mars. The "Jupiter" vehicle would marry a Lockheed spacecraft bus built for interplanetary probes with a robotic arm supplied by Canada's MacDonald, Dettwiler and Associates and a pressurized module built in Italy by Thales Alenia Space. Meanwhile, Boeing is offering a stripped-down version of the CST-100 Commercial Crew Vehicle as its CRS candidate.

India plans to conduct a test flight of its winged-body Reusable Launch Vehicle Technology Demonstrator later this year.


ARMEE DE UAIR

DEFENSE

France's bid to sell 126 Rafale jets to India advanced as Dassault Aviation and Hindustan Aeronautics Ltd. agreed to be co-contractors. The first 18 Rafales are to be built in France, with Hindustan taking over production of the remaining 108 Indian-built aircraft.

Korean Air Lines Co. secured Airbus as a technical partner for a last-minute bid to develop South Korea's KF-X indigenous combat aircraft, but will face an uphill battle competing against Korea Aerospace Industries, which is backed by Lockheed Martin (page 51).

The first Saab JAS 39E Gripen fighter jet is in final assembly at Linkoping, Sweden, with rollout now planned for 2016, a year later than originally expected. The delay will allow Brazil, which has ordered 36 Gripens, more time to prepare for its participation in the program. Brazil will begin taking deliveries in 2019.

After months of vague statements, Israel acknowledged that the Arrow-2 and Arrow-3 missile defense systems failed tests in the last months of 2014 (page 52).

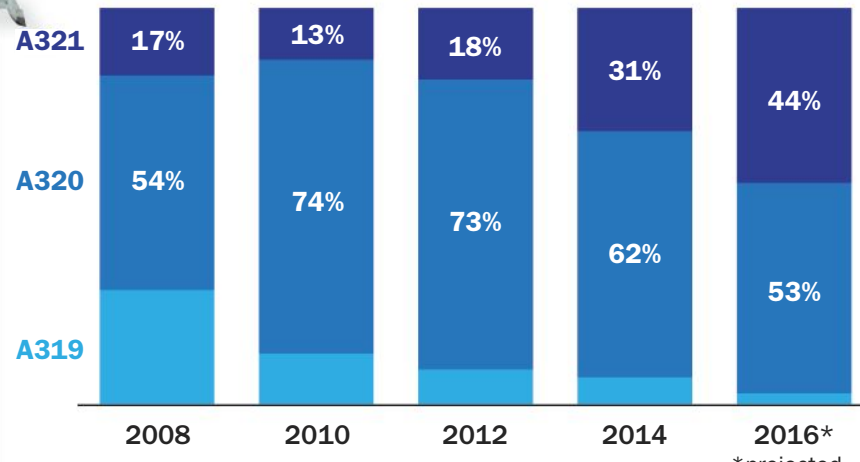
China plans to boost its defense spending by an inflation-adjusted 7%, and a crackdown on corruption should result in funds being spent more efficiently (page 33).

French defense procurement agency DGA has selected Airbus Defense and Space and Thales to co-prime design and construction of Europe's first operational space-based military signals intelligence system. DGA has budgeted €450 million ($478 million) to build and launch Ceres, a system of three closely positioned low-Earth orbit satellites, by 2020.

Europe's Neuron unmanned combat air system technology demonstrator has completed its 100-flight-test campaign in France and will move on to Italy and later Sweden, where weapons drop tests are planned later this year.

Boeing is expected to announce the winner of a multibillion-dollar program to modernize the F-15's electronic self defenses in May.

A320 Family Deliveries, in Unit Percentages



Airbus's narrowbody production has markedly shifted in favor of the largest variant of the A320 family, the A321, while hardly any A319s are being built. The company recently launched the A321LR, a long-range version of the A321neo, with Air Lease Corp. as the first customer.

Source: Airbus

TECHNOLOGY

Switzerland's Solar Impulse 2 has notched its first record on the second leg of its round-the-world attempt, setting a solar-powered distance record of 1,468 km (912 mi.) on the 13 hr., 20 min. flight from Muscat, Oman, to land in Ahmedabad, India, on March 10. Solar Impulse launched from Abu Dhabi on March 9, aiming to return there in two months (page 19).


SOLAR IMPULSE

49 YEARS AGO IN *AW&ST*

NASA's Gemini 8 mission, carrying astronauts Neil Armstrong and David Scott, conducted the first docking of two spacecraft in orbit on March 16, 1966, with an Agena target vehicle. But 27 min. after the docking, the vehicle went into a violent tumble, forcing the crew to abort the mission and make an emergency return to Earth.

Read our original coverage of Gemini 8 and other momentous events at: AviationWeek.com/100

Anthony L. Velocci, Jr.

Anthony L. Velocci, Jr., was editor-in-chief of Aviation Week & Space Technology *from 2003-12.*

COMMENTARY

Pound-Foolish

Long-term value creation taking backseat to short-term rewards

Short-term thinking seems to have become the strategy of choice for many publicly traded companies—including most of the larger aerospace concerns—as they fixate on share buybacks, above market-average dividends and free cash flow as the principal metrics of overall performance. Northrop Grumman, for one, is borrowing so it can expand its share-buyback program.

No one can argue that such strategies haven't delivered an impressive payback. Swimming in cash, the aerospace industry has been one of the best performing sectors in terms of shareholder value in each of the last five years, and stock prices for prime contractors are at or near 52-week highs.

Problem is these gains may be coming at the expense of creating long-term value in the form of new and more-innovative products that companies will need to be competitive. They also may be distorting investors' expectations. General Dynamics has one of the most aggressive share-buyback programs, while allocating a relative pittance toward independent research and development (IR&D).

"Leadership philosophies are mixed across the industry, but some companies are mainly interested in returns in as little as a year or two," says Frank Kendall, U.S. undersecretary of defense for acquisition, technology and logistics. Kendall is trying to figure out how to incentivize companies to be less risk-averse and focus more on long-range business opportunities—cyber, autonomy (air and undersea), data analytics and battery technology, among others—by investing more of their own resources in R&D.

Company-funded R&D has been about 2% of annual sales since 2003, according to Byron Callan, a director at Capital Alpha Partners and a leading independent analyst of the aerospace and defense sector. To put this into perspective, combined IR&D spending in 2014 by Boeing, Lockheed Martin, Northrop Grumman and Raytheon was about one-third of such investment by Google, one of the world's most technologically innovative companies.

U.S. NAVY

The short-term orientation is hardly surprising. Companies generally see longer-term strategies as too beset by uncertainty. Only short-term plans can have a real impact on business. Yet this logic hides a paradox: Preoccupation with the short term can lead to temporal myopia in which management can miss industry changes that erode long-term competitive positions.

This was not always the case. Larger companies used to be more accepting of the risks of developing new technology and were willing to take longer investment horizons. Perhaps Tom Jones, who was Northrop chairman and CEO from 1963 to 1990, embodied this spirit best, listing customers, employees and owners—in that order—as his priorities.

But the industry has changed dramatically, and not entirely for the better, since Jones and his peers called the shots. In today's hyper shareholder value-driven environment, investors are more apt to penalize a company than reward it if management moves to raise company-funded R&D investment to develop more innovative products to grow the business. "For the majority of primes, there isn't likely to be stepped-up R&D that materially impacts reported margins," Callan says.

But there are outliers. For example, in the late 1990s and early 2000s Raytheon boosted R&D investment around gallium nitride-based monolithic microwave integrated circuit technology to develop lighter, more capable high-power amplifiers, air and missile defense radars, and other sensors. Management did a good job articulating its technology roadmap to investors and other stakeholders, and positioned the company to win major contracts 5-10 years later.

In an apparent continuation of the same mindset, Raytheon will increase company-funded R&D investment in 2015, with a focus on the next generation of jammers, sensors and other advanced defense electronics for use in missiles such as the Tomahawk (see photo). Callan speculates the company may be inclined to take a more strategic view of how it creates value due to the makeup of its board of directors. They generally are individuals with more of a technology orientation than an industrials background, he says, and therefore have a keener appreciation for maintaining a robust technology-development pipeline.

In the growing dialogue about IR&D and whether it's sufficient to meet customer needs and ensure long-term competitiveness, it is chief executives who usually are on the defensive. But they serve at the behest of boards of directors, and maybe it is the latter that deserve to be in the hot seat. For example, how rigorously do they question the balance between long-term value-creation strategies and short-term financial gains? And how attentive are they to how future successes should be measured? Or are they just rubber-stamping whatever is put in front of them?

Obviously many factors drive performance, and it would be exceedingly difficult for any company to claim a direct causal link between longer-term planning and superior performance in and of itself. Rather, thinking longer-term creates an environment that can help shape performance-enhancing factors, and in that vein the buck stops with boards for their accountability, or lack thereof.

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LEAP

MORE TO BELIEVE IN

By Michael Bruno

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COMMENTARY

Private Power Brokers

Private equity increasing its activity to reshape the A&D industry

When engineering and systems integrator Science Applications International Corp. announced March 1 it was buying intelligence community services provider Scitor Corp. for $790 million, most news reports focused on how the deal marks a return to size and security work for SAIC.

After all, SAIC has enjoyed a Cinderella story since the old, Pentagon-focused organization renamed itself Leidos and split off technical and information technology businesses under the SAIC name in September 2013. At the time, Leidos was seen as having made off with the more promising part of the pre-split behemoth, starting with national security work and a new health-related venture.

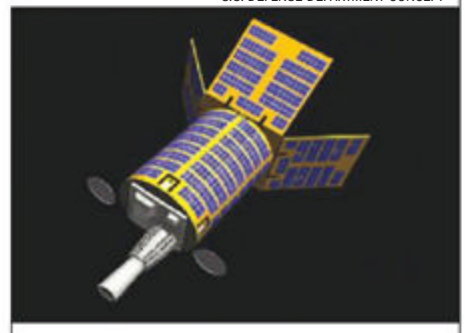
But then came sequestration spending caps and a government shutdown in October 2013, while post-split SAIC continued to impress Wall Street with its financial execution. Buying Scitor, the story goes, just adds a Leidos-type line of business back to SAIC without its baggage. That may be so, but the more interesting development may be who sold Scitor, why, and what it means for the rest of the aerospace and defense industry.

"The deal highlights another exit by private equity of a multiyear defense services investment," says analyst Byron Callan of Capital Alpha Partners. "We see this transaction as part of a normal consolidation process in defense services, which is still relatively fragmented."

SAIC's all-cash, negotiated acquisition of Scitor means a payout for private equity firm Leonard Green & Partners, which bought a majority position in Scitor in 2007. Leonard Green has invested in 72 companies, such as The Container Store and Petco, since its founding in 1989. The firm targets established companies that are leading their growth-oriented markets.

Many defense services companies in the mid-2000s met those conditions, so "sponsors" like Leonard Green stepped in. Now, roughly seven years later, they are at the end of the traditional time for private equity to exit their investments.

U.S. DEFENSE DEPARTMENT CONCEPT



Scitor has provided myriad support services for the Pentagon, including the Space-Based Infrared System missile warning system.

Last October, Engility and TASC unveiled a plan to merge in a $1.1 billion stock-and-debt deal. The deal was a welcome turn for Engility, which was spun off from L-3 Communications in mid-2012, and TASC, which Northrop Grumman sold to private equity owners General Atlantic and affiliates of Kohlberg Kravis Roberts in 2009. In 2013, CACI bought Six3 Systems from private equity firm GTCR for about $820 million. GTCR helped form defense intelligence services provider Six3 in July 2009.

In fact, the A&D practice at consulting giant PwC reported last month that investors were involved in six defense mergers or acquisitions worth more than $50 million each in 2014, compared with just two in 2013. "Private equity sellers were among the primary drivers of M&A activity in 2014, motivated by a desire to exit investments acquired prior to the financial crisis," says Scott Thompson, the firm's U.S. A&D Assurance leader.

In turn, more deals like Scitor appear on the way. According to Moody's Investors Service, 11 of the 14 defense services contractors rated by its analysts are partially or wholly sponsor-owned, and those private-equity owners want out. "Declining U.S. defense spending and heightened competitive pressures have proved to be far worse than what many financial sponsors had predicted at the time of their leveraged buyouts of service contractors," Moody's reported in November.

Along those lines, Moody's said their desire for an "adequate equity return" may pose another impediment to paying off debt. "The potential for a profitable exit has weakened with lower earnings and valuation multiples," Moody's said, referring to sequestration and other post-war pressures. "An elevated risk of transactions whereby creditors may incur losses should continue through 2016, including for DynCorp International [owned by Cerberus Capital Management], Scitor [Leonard Green] and SRA [Providence Equity Partners]."

Who else could be next? Callan notes that other defense businesses held by private equity for more than 2-3 years include Camber, Dyncorp International, PAE, Sotera Defense Solutions, SRA International, Vencore and Wyle.

Of course, not every move by private equity is an exit. "We're also seeing financial investors who have never played in the A&D space looking into defense-related deals as they're preparing to deploy their capital, which could potentially be another factor in driving M&A activity," Thompson said.

Indeed, the day after the SAIC-Scitor deal was announced, Rocket Lab said it completed a Series B financing round, led by venture capitalists Bessemer Venture Partners, with "full participation" from existing investors Khosla Ventures of California and the K1W1 investment fund in New Zealand, as well as a "strategic investment" from Lockheed Martin. Rocket Lab said it will use the funding to complete its two-stage, composite Electron system to launch 240-lb. payloads to orbit for less than $5 million per mission. It plans to begin operations as a commercial launch provider in 2016.

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COMMENTARY

After You

There's money and hardware, but little sense of urgency

Once fully up and running, NextGen, the FAA's satellite-based next-generation air traffic control system, promises users a host of benefits including more direct routing, fewer traffic delays, reductions in fuel consumption and emissions, and greater system capacity. Moreover, controllers will be able to track aircraft in areas where ATC radar coverage does not now exist.

In aircraft equipped to access such services, pilots will have real-time traffic displayed, receive subscription-free weather data and have access to new instrument approach procedures with extremely close tolerances. Another NextGen element is to be datacom, or a textual data link between controllers and aircraft.

To make all that come to fruition, FAA has been and is installing an elaborate, nationwide ground infrastructure with a high level of interconnectivity and interdependence. However, users must also invest in new equipment for their aircraft. And therein lies the rub.

As it has in the past, the FAA fell behind in implementing portions of the system, and that prompted many operators—airlines as well as business and general aviation users—to hesitate to install the needed equipage. Further, the cost of installation can be substantial. And lastly, some users, particularly light plane owners, perceive little benefit to them from equipping at all.

Even though the FAA has insisted that one key piece of airborne equipment, namely Automatic Dependent Surveillance-Broadcast (ADS-B) Out, would be mandatory for any aircraft to enter controlled airspace as of Jan. 1, 2020, many believed that deadline would eventually slip.

None of this seems to surprise Michael Dyment. Founder and managing partner of NEXA Capital and a lapsed pilot with a master's degree in Aeronautics and Astronautics from the Massachusetts Institute of Technology, he has spent much of his career focused on the aerospace industry. Beginning as a GPS avionics engineer and product manager at Canadian Marconi, he went on to advise such industry luminaries as Boeing, Lockheed Martin, Northrop Grumman, NetJets and the National Business Aviation Association, as well as federal entities, including the FAA.

Michael Dyment

In 2011, with the aviation industry struggling through the deep recession and showing little appetite for upgrading aircraft, Dyment seized on the idea of establishing a special fund to help finance and accelerate NextGen equipment installations. His idea proved prescient since the FAA reauthorization act passed the following year included federal loan guarantees for such upgrades.

Dyment went on to create the NextGen Equipage Fund and the NextGen GA Fund, for accommodating the airlines and general aviation, respectively, in partnership with major lenders and investors. Yet despite having money to lend—$550 million in the GA fund—and the clock ticking down to a deadline now less than five years off, there have so far been relatively few takers. The reasons for that are several.

Largely profitable again, the airlines are simply self-financing their ADS-B upgrades; but they are cool to datacom. Meanwhile, the FAA has balked at guaranteeing loans for general aviation upgrades, insisting the legislation for that is flawed—a position Dyment sees as a "phantom issue" that threatens high-end upgrades and which he says will be resolved legislatively this summer.

However, the obstacle blocking compliance for the majority of the general aviation fleet remains the cost. The Aircraft Owners and Pilots Association (AOPA) estimates an ADS-B upgrade for a light aircraft costs about $5,000, a relatively high figure since it says more than 80,000 such aircraft are valued at $40,000 or less.

Even though from the outset Dyment's funds targeted larger aircraft, he viewed the de facto grounding of so many aircraft come the 2020 deadline as a "train wreck" for NextGen. He felt it was imperative "to take away the argument that ADS-B is too expensive."

And so he created the "Jumpstart GA 2020" program, in which five avionics makers were invited to submit bids to supply the fund with 10,000 low-cost ADS-B units. In February, Jumpstart announced L3 Aviation's Lynx NGT-1000 (top photo) as the winner, with a dealer price of $1,599 per unit.

An AOPA spokesman says of the Jumpstart program, "At a minimum, it's certainly a step in the right direction."

Meanwhile, Dyment is hoping for quick-stepping by many, since less than 58 months remain to equip some 150,000 general aviation aircraft. Getting all those machines ADS-B-compliant by the deadline—which the FAA adamantly insists will not be delayed—requires 2,500 upgrades per month, which is a far higher rate than has been realized to date.

For those still reluctant to upgrade, Dyment says the time has arrived "to bring your general aviation aircraft into the 21st century."

By Jens Flottau

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COMMENTARY

Harsh Reality

U.S. industry drive against Gulf carriers shows need for an airline trade pact

If you wonder what the U.S. campaign against Gulf carriers will resemble, look back at the public relations initiatives taken by three major American airlines and labor against a foreign air carrier permit for Norwegian Air International (NAI). The new campaign will likely be on every channel, so to speak, and the only major difference between the NAI and Gulf cases will be that airlines will be in the forefront, rather than the Air Line Pilots Association.

Now that there is even a letterhead that the industry will see many times in the next months and years, it is clear that U.S. airlines are prepared to spend many millions in their efforts to find a regulatory way to stop Gulf carriers. That is what the "Partnership for Open and Fair Skies" is about. This column has recently discussed the situation and the many reactions to show its importance to the industry. Therefore a few further remarks:

The U.S. airlines—American, Delta and United—claim they are still in favor of "open skies." But the carriers say the enormous amount in government subsidies received by their Gulf competitors justifies an exception to open skies to allow a rollback of traffic rights. That's where things really start to get tricky from a systematic point of view: Assuming all the claims are accurate, this case is currently the most painful for U.S. and European airlines. But that in itself cannot be an argument for regulatory action. And is it the worst case ever?

Not really. The governments of India, China and South Africa, to name a few, have injected many billions into their own airlines and some continue to do so. The difference between them and Emirates—which, according to the partnership for open skies, has received $5 billion in support over the years—is that American, Delta and United airlines could not care less about another billion for Air India or South African. They just either fly below the radar or are strategically important alliance partners.

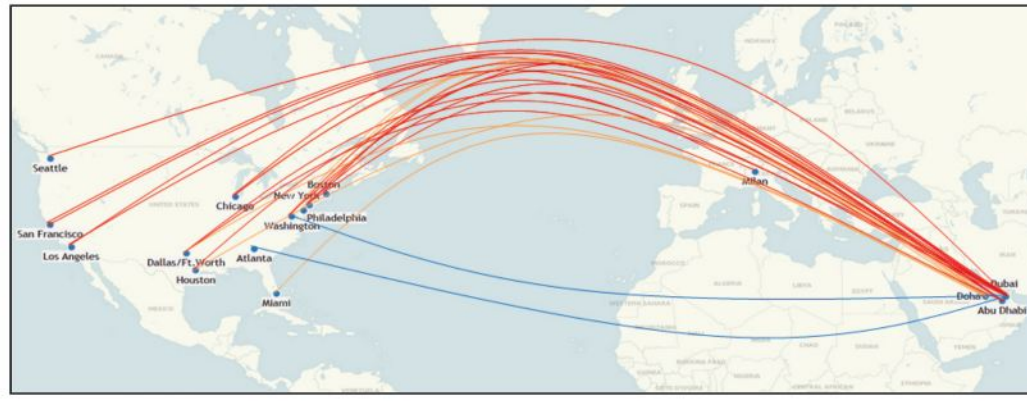
If some airlines, like Qatar or Etihad, have essentially unlimited access to equity and others don't, it is understandable that competitors are crying foul. But it is enormously difficult to argue that a very rich investor should not put more money into an airline if he chooses. Systematically, it cannot matter whether that investor is a state or a private enterprise.

What is lacking in the airline industry is an effective international trade agreement that regulates such issues. Ideally, support for airlines should be regulated only by an international and multilateral pact.

In negotiations, more support mechanisms would be brought to the table such as the option to file for Chapter 11 bankruptcy protection in the U.S. Airlines in the rest of the world have been complaining about this process for years because they don't have the option of ridding their balance sheets of billions in debt within a few months or a year. Even the allocation of traffic rights is an effective and popular way to support a local airline. But with no basic understanding of where and how an airline benefits and suffers, it is unlikely an agreement will be reached about what is fair.

The U.S. coalition wants to establish "a level playing field for all," but that is wishful thinking. In the absence of a more or less global deal, the playing field will always be uneven because interests, countries, legislation and habits differ. Airlines worldwide have had to live with this situation for decades and it likely will continue for a long time.

U.S. and Gulf Carrier Services to the U.S.



Notes: Emirates and Etihad flights are shown in red; Qatar flights in orange; and U.S. airline flights in blue.
Source: OAG, December 2014

By Pierre Sparaco

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

COMMENTARY

Misreading the Backlog Situation

IATA: Curtail production now to avoid telltale sign of overcapacity—white tails

One would be hard-pressed to find an industry segment that sells twice as many products as it produces, yet Boeing and Airbus are doing just that. The archrivals have enjoyed unprecedented success in the commercial transport market in the past several years and have repeatedly increased their production rates to a combined 100 single-aisle twinjets.

AIRBUS/PPIGEYRE

Airbus A320-series final assembly lines are located in Hamburg (shown), Toulouse and Tanjin, China.

Airbus has now decided to boost production to 50 A320s per month, up from 42; the manufacturer is scheduled to soon begin delivering aircraft assembled in Alabama in addition to aircraft coming off assembly lines in Hamburg and Toulouse as well as Tanjin, China.

The European manufacturer holds firm orders for 6,386 narrowbody twinjets. The huge backlog includes 1,456 contracts signed in 2014; 456 aircraft were delivered. The contrast between intake and outgo is jarring. The manufacturer may be selling more aircraft than it can deliver, putting its customer airlines on track for huge fleet problems somewhere down the line. Or perhaps the analysts' long-term capacity-need assessments were far too rosy.

At the current production rate, delivering the A320s already in the backlog would take at least 150 months, an absurd situation. In the interim, some customers could simply disappear—mergers or bankruptcies are virtually guaranteed in some markets—and the airline industry could suffer from record-breaking overcapacity.

Obviously, Airbus (and Boeing) do not acknowledge this possibility publicly; however, it is certainly being discussed behind closed doors. On several occasions in the last 10 years, top executives, including Giovanni Bisignani, then-chairman/CEO of the powerful International Air Transport Association (IATA), have urged that production rates be cut to avoid white tails.

Manufacturers rejected such pessimistic views, averring that a sudden turnaround is highly improbable. Moreover, they state, in case of mass cancellations, the backlog would nevertheless be strong enough to maintain the current production pace.

In other words, at this point both key airline manufacturers are opting to restrict some production dates despite robust demand. The rivals share certain traits: They monitor their backlogs well and protect the identities of their customers, of which more than a few could be facing bankruptcy within the next few years.

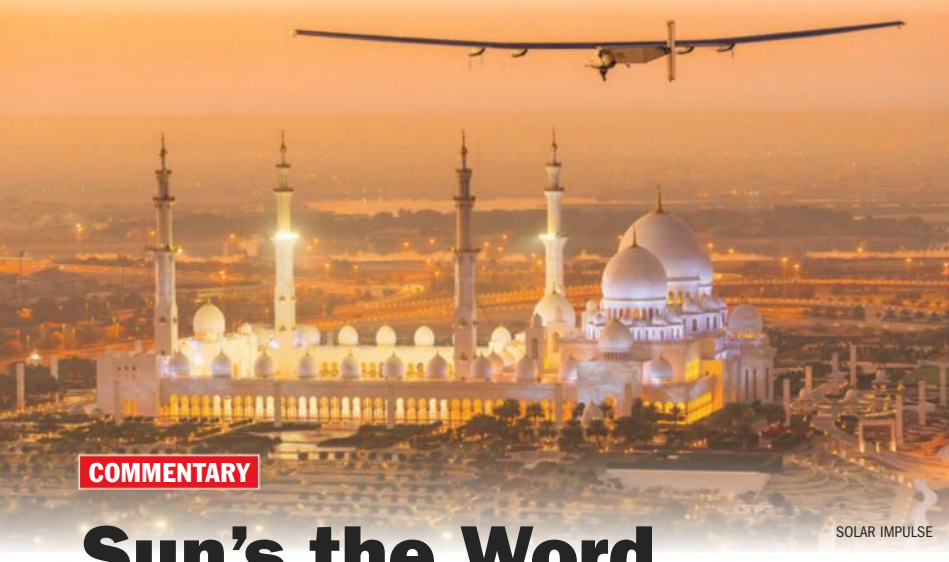
Engine manufacturers face a similar dilemma. Snecma's record backlog comprises 13,000 CFM56s and Leaps, while its average production rate is 1,560 per year. This is impressive but certainly not enough to maintain realistic delivery rates. The ultimate goal, which it downplays, is to refrain from overcapacity.

Adopting the broader view, difficulties are systemic, and run deep and wide. The prime contractors are the focal point for industry analysts who detail the market's moves daily. However, they seem to be underestimating the impact on the supply chain. Myriad small companies are involved, many of which are under-capitalized because banks are reluctant to support their growth. Either the banks have sized up the problem realistically or are being too prudent.

While Airbus and Boeing make headlines when they secure orders for hundreds of aircraft, their partners and suppliers are barely mentioned. This could be the analysts' biggest blunder. Global industry giants—IATA, the International Civil Aviation Organization, the Association of European Airlines and Aerospace ID Technologies Program—along with regional trade groups, all see air traffic growing at about 5% per year in the next 20 years, barring a global catastrophe.

The best aviation economists can't be all wrong. Year after year, noted experts in Toulouse and Seattle, supported by their colleagues in Geneva and Montreal, project airline growth at a robust 5% or more.

However, there is no doubt: Someone is wrong.



SOLAR IMPULSE

COMMENTARY

Sun's the Word

Can a one-off aircraft for a unique challenge have wider relevance to aviation?

Abu Dhabi is an appropriate place for launching an attempt to fly around the world on solar power. But after leaving the sun-drenched desert of the United Arab Emirates, Switzerland's Solar Impulse 2 (Si2) quickly faces the real world of changing weather and night flying. Which is why solar energy is not a practical power source for aviation—or is it?

Solar Impulse is less an everyday aviation endeavor than an environmental rallying call, the round-the-world flight intended to inspire enthusiasm for renewable energy and sustainable technology. But Si2 itself is an aerospace achievement: an all-composite aircraft with the weight of a car, a wingspan greater than a Boeing 747's and the most efficient propulsion system yet flown.

From Abu Dhabi, Si2 is planned to fly almost 19,000 nm (35,000 km) in 25 flight days over five months, with stops in Oman, India, Myanmar, China, Hawaii, the continental U.S., and Southern Europe or North Africa, before returning to Abu Dhabi. Solar Impulse co-founders Andre Borschberg and Bertrand Piccard will take turns flying, alone in an unheated, unpressurized cockpit for up to five days and nights.

Solar Impulse prototype HB-SIA was the first solar-powered manned aircraft to fly for more than 24 hr., proving the solar cells and batteries could collect and store enough energy to fly through the night. Si2, registered HB-SIB, has been designed to extend that capability to multiple days while enabling the pilot to rest, exercise and stay alert over the long flights.

With a span of 236 ft., the wing has a high aspect ratio to maximize aerodynamic efficiency, but Si2 weighs only 5,070 lb. and slightly more than a quarter of that is for the batteries. The airframe is made of carbon fiber and honeycomb; the single wingspar is 230 ft. long with 140 ribs spaced 20 in. apart to maintain the airfoil shape and rigidity. Carbon-fiber sheets weighing just 0.07 oz./sq. ft. were used in construction.

A total of 17,248 monocrystalline silicon solar cells are encapsulated in the upper-surface skins of the wing, tail and fuselage. Operating at 23% efficiency, these generate electricity to be stored in 1,395 lb. of lithium-polymer batteries housed in the nacelles for the four 17.4-hp brushless electric motors. These drive 13-ft.-dia. propellers at 525 rpm via reduction gears. Overall efficiency is a record 94%, says Solar Impulse.

The round-the-world attempt is as much about the pilot's endurance as the aircraft's. Compared with the prototype, Si2 has a much larger, 134-cu.-ft. cockpit to allow the pilot to move around, and the seat, which also functions as a toilet, allows him to exercise when fully reclined. The aircraft flies up to 28,000 ft. during the day, requiring oxygen, and descends to 5,000 ft. at night to save energy.

The pilot is allowed to sleep. A monitoring and alerting system continuously checks the autopilot and will alert the pilot via a vibrating sleeve if bank angle exceeds a limit of 5 deg. Another system controls the charging thresholds and temperatures in the batteries to prevent a thermal runaway. Aircraft data are telemetered continuously to the Solar Impulse mission control center (MCC) in Monaco.

The MCC is responsible for all decisions on departures and routes, and for monitoring aircraft status and position, and the pilot. Si2 has a limited flight envelope, its low wing-loading making it sensitive to turbulence. Takeoffs and landings are at night to minimize bumpiness, and wind speeds must be less than 10 kt. The average cruise speed is expected to be only 30-55 kt.

None of that sounds like a practical aircraft. But Solar Impulse is making a statement about sustainable energy and climate change. And solar-powered aircraft are coming, although much smaller than Si2. The obvious application is to unmanned aircraft, with Google to begin tests this year of high-altitude, long-endurance UAVs for Internet delivery under Project Titan.

But there are manned aircraft, too. Colorado-based Aero Electric Aircraft is developing the Sun Flyer solar-electric training aircraft, flying a single-seat demonstrator while a two-seat prototype is built. The first two-seat solar-powered aircraft to fly is Solar Flight's Sunseeker Duo. Low operating cost and noise are benefits. Performance is low, if perhaps adequate for a trainer or recreational aircraft.

But solar power could impact commercial aviation if hybrid turbine/electric propulsion becomes a reality. A Boeing study for NASA suggests the environmental benefits of hybridization are only substantial if the grid power used to recharge the batteries comes from renewable sources. So Solar Impulse's message about solar power and sustainability may yet prove significant for air transport.

By Graham Warwick

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COMMENTARY

Prove It

Marines' Stovl plans should be tested early

The Lockheed Martin F-35B, the short-takeoff, vertical-landing (Stovl) version of the Joint Strike Fighter, has the shortest range and the smallest payload of the three variants. It's also the most expensive. The Stovl and carrier shipboard requirements determined the F-35's wingspan and length, dictated the use of a single engine and drove the internal layout of the fuselage.

U.S. Marine Corps leaders have been confident that the F-35B alone will deliver strategic options that justify its price and impact on the Air Force and Navy versions. That's a tall order. A Marine expeditionary force is organized around a single amphibious warfare ship, a Landing Helicopter Dock or a Landing Helicopter Assault. These are big warships but they also carry Marines, their equipment and helicopters. Normally, the air combat element includes just six AV-8B Harriers, and no force of six aircraft has won a war yet.

The idea behind the Marine Harrier force always has been that it can expand beyond the ship's capacity, by using shore bases that other fighters cannot reach: short civilian runways or even stretches of road. This kind of operation has been performed by the Marines, in combat, exactly three times in the 40-year history of the Harrier force.

The question today is simple: What scenario can we contemplate where you need supersonic, stealthy multi-role fighters, but you don't need the full carrier air wing? In the past few months, the Marines have rolled out some potential answers.

Corps Commandant Gen. Joseph Dunford told the House defense appropriations subcommittee in late February that a shipboard detachment of 4-8 F-35Bs would deliver "the same kind of access" in "high-risk regions" as a joint strike package today that would include "cruise missiles, fighter aircraft, electronic-warfare platforms, aircraft which specialize in suppression and destruction of enemy air defenses, and strike aircraft." The F-35 detachment is "a Day-One, full-spectrum capability against the most critical and prohibitive threats," Dunford said.

On land, the Marines would use a new concept of operations known as distributed Stovl operations (DSO), according to Lt. Gen. Jon Davis, deputy commandant for aviation. The idea behind DSO is to obtain the advantages of forward-basing—deeper reach and faster response—while keeping people, aircraft and equipment on the ground safe from counter-attack from threats that are likely to include guided tactical ballistic missiles.

Mobility is the key. The plan calls for mobile forward-arming and refueling points (M-Farp) that can be moved around the theater inside the adversary's targeting cycle—assumed to be 24-48 hr.—so they can survive without active missile defense. Decoy M-Farp would be established to complicate the targeting problem.

Dunford's eight-aircraft detachment would be kept busy sustaining combat air patrols, providing over-the-horizon intelligence, surveillance and reconnaissance (ISR), and performing close air support and strike. Britain's new aircraft carriers are 70,000-ton ships because the operations analysts calculated that a stand-alone air wing would need 24 aircraft to cover those missions.

Without a carrier, Dunford's force has no persistent ISR or airborne early warning (AEW)—and any nation qualifying as a high-risk threat will have antiship cruise missiles (ASCM) on fast attack craft, on trucks or masked in commercial containers. AEW was invented because by the time ASCM or kamikazes appear on the horizon, it's too late.

DSO sounds like an adventure in logistics. The Marines' biggest off-base Harrier operation, in 1991 during Desert Storm, was supported by 45 8,000-gal. tanker trucks, and the F-35B is more than twice the Harrier's size. Davis envisages that in some cases, the M-Farp will be supplied by KC-130J tankers, but each of their sorties will deliver five F-35B-loads of fuel at best. As was finally confirmed in the run-up to last year's Farnborough air show (*AW&ST* May 26, 2014, p. 15), the F-35's exhaust is tough on runways; many tons of metal planking will be needed to protect poor-quality runways or roads, even in a rolling vertical landing. It will have to be moved on the same cycle as the rest of the M-Farp.

Force protection could be a challenge. The M-Farp will need either a huge sanitized zone or its own active defense against rockets, mortars and shoulder-fired anti-aircraft missiles, which no practical decoy or jammer will distract from the F-35B's exhaust.

These ambitious operational concepts should be tested, in force-level exercises against an aggressive and independent Red team, before we get much further into the $48 billion F-35B procurement. There could be no better use for the first F-35B squadron, once Marine leaders declare it ready for combat later this year.

By Frank Morring, Jr.

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COMMENTARY

ISS Toll Booth

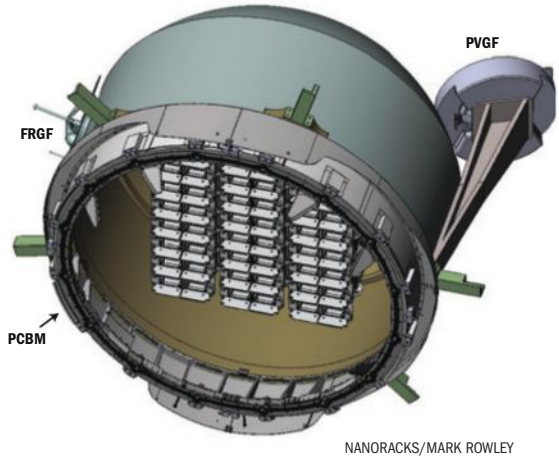
Private company plans a private airlock

NanoRacks, which pioneered commercial payload accommodation on the International Space Station (ISS), has been working with NASA on the design and specs for a second way to move cargo from the ISS's pressurized volume out into the vacuum of space. The company plans to open bidding for its "Bishop" airlock soon, to support delivery on orbit by the end of 2017.

The move is in keeping with the U.S. space agency's desire to increase the commercial use of the ISS in hopes it will pave the way for a private follow-on to the orbiting laboratory. NanoRacks already is thinking along those lines too.

"For us this is a logical next step, leading to one day when we would operate in some manner our own platform," says Jeffrey Manber, NanoRacks' founder and CEO.

NanoRacks' Bishop Airlock



NANORACKS/MARK ROWLEY

NanoRacks, which has a staff of 40 and an expected $25 million orderbook this year, was one of the first companies to take advantage of the free transportation to orbit and on-board accommodation NASA is offering. Starting with a simple power-and-data "NanoRack" for cubesat-size payloads, it has expanded its offerings inside the station to include a small centrifuge, a microscope, a plate reader and simple fluid-mixing enclosures known as "MixStix." On the exterior it offers payload accommodations mounted on the exposed facility of the Kibo Japanese Experiment Module (JEM), and a cubesat dispenser, which are accessible via Kibo's airlock and robotic arm.

That pathway in and out of the station is becoming too narrow to meet demand, according to NanoRacks Chief Technology Officer Michael Johnson, who is leading the Bishop airlock development.

"We have a wonderful problem in that we have too much demand commercially for the JEM airlock, so we started looking at the idea of creating another airlock that was much larger," Johnson says.

To supplement the Kibo airlock, NanoRacks is working with the ISS program office at Johnson Space Center on a "bell jar" airlock (see illustration). The Bishop airlock would ride to orbit in the unpressurized "trunk" of the last SpaceX Dragon vehicle purchased by NASA under the current commercial resupply services (CRS-1) contract. It would be attached to the port-side common berthing mechanism on the station's pressurized Node 3 (Tranquility) with a standard passive common berthing mechanism (PCBM) fixture. From there, the station's Canadian-built main robotic arm would move it around as needed, like its namesake chess piece.

Station crewmembers would transfer newly arrived external cargo through the berthing-mechanism hatch from Tranquility, close the hatch, and then use Bishop's vacuum pump to evacuate about 80% of the air inside for recycling (the remaining 20% would be bled off) before unberthing it to expose the payload to the vacuum of space.

Potential cargo includes dispensers for cubesats and larger ESPA-class spacecraft; sensors and other hardware for the planned commercial Muses (Multi-User System for Earth Sensing) that is in development by Teledyne Brown Engineering and the German Aerospace Center DLR, and some government orbital replacement units (ORU) for the station.

When the hardware is in place and the air evacuated from the "bell jar," the station robotic arm would grapple its power and video grapple fixture (PVGF) and move it where it needs to go. For satellite deployments, that would be down toward Earth at a 45-deg. angle, facing in the opposite direction from the station's orbit to minimize the chance of recontact.

For ORUs or Muses hardware, the arm would park the Bishop using a passive flight releasable grapple fixture (FRGF) on its side, and the crew would use the Dextre special purpose dexterous manipulator robot and the station arm to remove the cargo and install it, and then return the airlock to its berth on Tranquility. The process could be reversed to bring ORUs or other exterior hardware inside the station for repair or replenishment.

The Bishop would weigh about 2,500 lb. and could fit into the unpressurized trunk on a SpaceX Dragon, according to preliminary engineering NanoRacks has conducted in association with the ISS program office. It would have an internal diameter of 70 in., and measure 68 in. from front to back.

To recoup the estimated $10 million cost of the Bishop airlock, Manber says NanoRacks would consider it as a sort of "space toll booth."

"We would not charge our customers; it would be part of our fee," he says. "We are still working through what is a good price for charging third parties that do not use NanoRacks. And I imagine there would be a complex symbiotic relationship with NASA."

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COMMENTARY

Matter of Interpretation

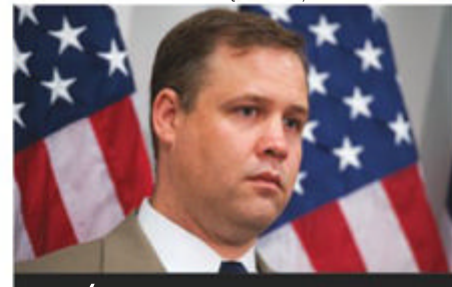
Air Force, lawmaker at odds over C-130 mods

Congress can write laws, while allowing the administration plenty of ways to get around them. For several years, the Air Force and Congress have been fighting over the fate of the C-130 Avionics Modernization Program (AMP). Lawmakers including Rep. Jim Bridenstine (R-Okla.) have tried to force the Air Force to fully fund the program to bring C-130H airlifters into the digital age, but the Air Force has sought to cancel it. Last year, the defense authorization act included a section that prohibits the Air Force from canceling or changing the AMP program—except if the defense secretary certifies the change is needed to make the aircraft consistent with FAA requirements.

Bridenstine is attempting to hold the Air Force to the prohibition, to no avail. During a March 4 hearing, Air Force officials told Bridenstine the service will add the radios, voice recorders and other equipment to meet FAA air traffic management standards. The implication is that the Air Force will stop short of the AMP's complete digital overhaul. Bridenstine said the law would restrict 15% of the Air Force's operation and maintenance budget if the service did not fully fund the AMP overhaul. "We have a different interpretation about what that language means," Air Force acquisition chief William LaPlante replied.

For Bridenstine, a former Navy E-2 and F/A-18 pilot and reservist, this is another example of unfairness. He started out on a propeller aircraft and moved to Hornets, bearing witness to the fact that "pointy-nose jet aircraft" get the most modern avionics. He has also seen the difference in how active-duty forces are treated relative to reservists. Now that he is an elected official, Bridenstine has had enough. "I get really frustrated when I hear the Pentagon tell members of Congress 'if we go forward with this program that's going to cost us X number of KC-10s or force us to retire the A-10 fleet,'" he says. "These are absolutely false choices to bully us into going along with their plan."

CQ ROLL CALL/NEWSCOM FILE PHOTO



'These are absolutely false choices.'

—REP. JIM BRIDENSTINE

CHINA CALLING

The congressional ban on NASA cooperating with China in space will fall eventually, predicts Administrator Charles Bolden, who terms the present state of affairs "unfortunate." China is "a very capable nation, very competent," he tells a questioner at the American Astronautical Society's Goddard Memorial Symposium March 11. "At some time in the future, I think we will reach out, or accept the overtures, and China will become a member of the family of spacefaring nations," says Bolden, who made a quiet visit to China last fall (*AW&ST* Dec. 15, 2014, p. 11). But even though he met with Wang Zhaoyao, the director of the China Manned Space Engineering Office, Bolden concedes that cooperation in human spaceflight "probably won't happen in my tenure as the NASA administrator." Based on directions from President Barack Obama, Bolden says, NASA is "looking every day to expand the number of . . . nontraditional partners." Bolden recently traveled to Latin America for discussions with officials in Argentina, Brazil, Colombia and Peru. Congress allows NASA to participate in multilateral projects that include China, but John Culberson (R-Texas), the new chairman of the House Appropriations subcommittee that funds NASA, says he intends to maintain and possibly expand the prohibitions drafted by his predecessor on human rights and national security grounds (*AW&ST* March 6, p. 24).

AIR TRAFFIC INSECURITY

In the run-up to drafting an FAA reauthorization bill, Sen. Charles Schumer (D-N.Y.) is calling on the agency to shore up the security of its air traffic control (ATC) systems. On March 2, the Government Accountability Office released a report citing "significant security control weaknesses" within the FAA's computer systems. Those weaknesses include failure to encrypt sensitive data, failure to implement the FAA's own security policies, inadequate testing of servers and software, and an outmoded risk-management process. These "leave the agency's ATC systems vulnerable to hacking, which could expose sensitive aviation data or even shut down the system while thousands of planes are in the air," Schumer says. The government watchdog agency offered 17 suggestions to boost security. A chance to write them into law is coming. The current FAA policy bill expires in September.

STILL SEARCHING

Sen. Kelly Ayotte (R-N.H.), who leads the Senate Commerce aviation subcommittee, continues to apply pressure to the administration to formally appoint a new head of the Transportation Security Administration (TSA) to replace John Pistole, who left office at the end of 2014. Ayotte has interim Administrator Melvin Carraway set to testify at a March 17 hearing and discuss TSA's Pre-Check program, a potential passenger security fee increase and other issues.

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Aerodynamic upgrades to the Boeing 777 include a redesign of the inboard flap fairing, slat trailing edge and deletion of the tail skid.

TONY OSBORNE/AW&ST

Sharpened Edge

Two-year 777 upgrade implementation plan draws from venerable aircraft predecessors

Guy Norris **Los Angeles**

Ever careful with its stewardship of the cash-generating 777 program, Boeing is planning a series of upgrades to ensure the aircraft remains competitive in the long-range market well after the 777X derivative enters service.

The plan, initially revealed in January, was laid out in detail by Boeing on March 9 at the International Society of Transport Air Trading meeting in Arizona. Aimed at providing the equivalent of 2% fuel-burn savings in baseline performance, the rolling upgrade effort will also include a series of optional product improvements to increase capacity by up to 14 seats, which will push the total potential fuel-burn savings on a per-seat basis to as much as 5% over the 777-300ER by late 2016.

At least 0.5% of the overall specific fuel-burn savings will be gained from an improvement package to the aircraft's GE90-115B engine, the first elements of which General Electric will test later this year. However, the bulk of the savings will come from multi-tier changes to reduce aerodynamic drag and structural weight. Additional optional improvements to the cabin will also provide operators with more seating capacity and upgraded features that would offer various levels of extra savings on a per-seat basis.

"We are making improvements to the fuel-burn performance and the payload/range and, at same time, adding features and functionality to allow the airlines to continue to keep the aircraft fresh in their fleets," says Larry Schneider, vice president and chief project engineer for the 777. The upgrades, many of which will be retrofittable, come as Boeing continues to pursue new sales of the current-generation twin to help maintain the 8.3-per-month production rate until the transition to the 777X at the end of the decade. Robert Stallard, an analyst at RBS Europe, notes that Boeing has a firm backlog of 273 777-300s and 777Fs, which equates to around 2.7 years of current production. "We calculate that Boeing needs to get 272 new orders for the 777 to bridge the current gap and then transition to the production phase on the 777X," he says.

The upgrades will also boost existing fleets, Boeing says. "Our 777s are operated by the world's premier airlines and now we are seeing the Chinese carriers moving from 747 fleets to big twins," says Schneider. "There are huge 777 fleets in Europe and the Middle East, as well as the U.S., so enabling [operators] to be able to keep those up to date and competitive in the market—even though some of them are 15 years old—is a big element of this."

Parts of the upgrade have already been introduced; the remainder are due by the third quarter of 2016. "There is not a single block point in 2016 where one aircraft will have everything on it. It is going to be a continuous spin-out of those capabilities," Schneider says.

The overall structural weight of the 777-300ER will be reduced by 1,200 lb. "When the -300ER started service in 2004 it was 1,800 lb. heavier, so we have seen a nice healthy improvement in weight," he adds. The reductions have been derived from production-line improvements introduced as part of the move to the automated drilling and riveting process for the fuselage, which Boeing expects will cut assem-

bly flow time by almost half. The manufacturer is adopting the fuselage automated upright build (FAUB) process as part of moves to streamline production ahead of the start of assembly of the first 777-9X in 2017.

One significant assembly change is a redesign of the fuselage crown, which follows the simplified approach taken with the 787. "All the systems go through the crown, which historically is designed around a fore-and-aft lattice system that is quite heavy. This was designed with capability for growth, but that was not needed from a systems standpoint. So we are going to a system of tie rods and composite integration panels, like the 787. The combination has taken out hundreds of pounds and is a significant improvement for [line] workers who install it as an integrated assembly," Schneider says. Other reductions will come from a shift to a lower-weight, less-dense form of cabin insulation and adoption of a lower-density hydraulic fluid.

Boeing has also decided to remove the tail skid from the 777-300ER as a weight and drag reduction improvement after developing new flight control software to protect the tail during abused takeoffs and landings. "We redesigned the flight control system to enable pilots to fly like normal and give them full elevator authority, so they can control the tail down to the ground without touching it. The system precludes the aircraft from contacting the tail," Schneider says. Although Boeing originally developed the baseline electronic tail skid feature to prevent this from occurring on the -300ER, the "old system allowed contact, and to be able to handle those loads we had a lot of structure in the airplane to transfer them through the tail skid up through the aft body into the fuselage," he adds. The weight saving is significant, he notes.

The change was implemented on the line in November and will be offered as a retrofit via a service bulletin. "With a retrofit, you can't save so much weight because the structure is already in the fuselage, but the drag and maintenance savings is still a nice benefit" for customers, says Schneider.

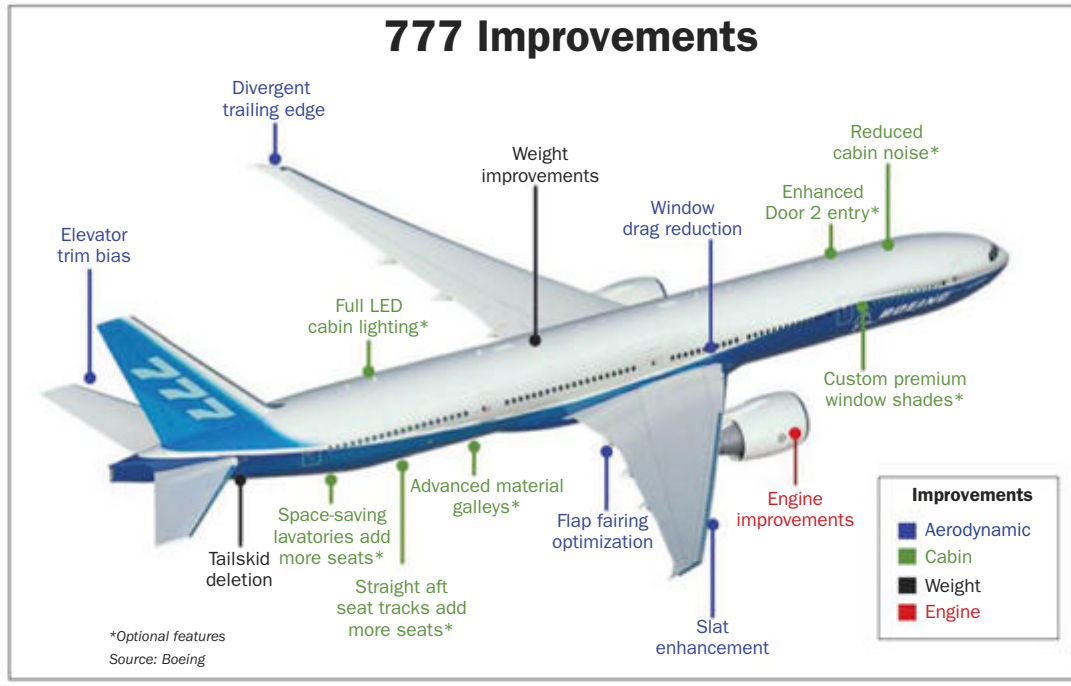
A series of aerodynamic changes to the wing based on design work conducted for the 787 and, perhaps surprisingly, the long-canceled McDonnell Douglas MD-12, is reducing the drag of the 777. The most visible change, which astute observers will also be able to spot from below the aircraft, is a 787-inspired inboard flap fairing redesign.

"We are using some of the technology we developed on the 787 to use the fairing to influence the pressure distribution on the lower wing. In the old days, aerodynamicists were thrilled if you could put a fairing on an airplane for just the penalty of the skin friction drag. On the 787, we spent a lot of time working on the contribution of the flap fairing shape and camber to control the pressures on the lower wing surface."

Although Schneider admits that the process was a little easier with the 787's all-new wing, Boeing "went back and took a look at the 777 and we found a nice healthy improvement," he says. The resulting fairing will be longer and wider, and although the larger wetted area will increase skin friction, the overall benefits associated with the optimized lift distribution over the whole wing will more than compensate. "It's a little counterintuitive," says Schneider, adding that wind-tunnel test results of the new shape showed close correlation with benefits predicted by computational fluid dynamics (CFD) analysis using the latest boundary layer capabilities and Navier-Stokes codes.

Having altered the pressure distribution along the underside of the wing, Boeing is matching the change on the upper surface by reaching back to technology developed for the MD-12 in the 1990s. The aircraft's outboard raked wingtip, a feature added to increase span with the development of the longer-range variants, will be modified with a divergent trailing edge. "Today it has very low camber, and by using some Douglas Aircraft technology from the MD-12 we get a poor man's version of a supercritical airfoil," says Schneider. The tweak will increase lift at the outboard wing, making span loading more elliptical and reducing induced drag.

Boeing has been conducting loads analysis on the 777 wing to "make sure we understand where all those loads will go," he says. A related loads analysis to evaluate whether the revisions could also be incorporated into a potential retrofit kit will be completed this month. "When we figure out at which line number those two changes will come together [they must be introduced simultaneously], we will do a single flight to ensure we don't have



any buffet issues from the change in lift distribution. That's our certification plan," Schneider says.

A third change to the wing will focus on reducing the base drag of the leading-edge slat via a version with a sharper trailing edge. "The trailing-edge step has a bit of drag associated with it, so we will be making it sharper and smoothing the profile," he explains. The revised part will be made thinner and introduced in mid 2016. Further drag reductions will be made by extending the seals around the inboard end of the elevator to reduce leakage and by making the passenger windows thicker to ensure they are fully flush with the fuselage surface. The latter change will be introduced in early 2016.

In another change adopted from the 787, Boeing also plans to alter the 777 elevator trim bias. The software-controlled change will move the elevator trailing edge position in cruise by up to 2 deg., inducing increased inverse camber. This will increase the download, reducing the overall trim drag and improving long-range cruise efficiency. "We did that with the 787-9, and the 777 has basically the same horizontal tail airfoil as the 787, so we said it should work just as well on the 777 as on the 787." The technology to implement it is being reused, resulting in a significant cost saving, Schneider says.

The package of changes means that range will be increased by 100 nm or, alternatively, an additional 5,000 lb. of payload can be carried. Some of this extra capacity could be used for changes in the cabin that could add 14 seats. The extra seating, which will increase overall seat count by 3%, could feature the option of arm rests integrated into the cabin wall. Schneider says the added seats, on top of the baseline 2% fuel-burn improvement, will improve total operating efficiency by 5% on a block fuel per-seat basis.

Other cabin change options will include repackaged Jamco-developed lavatory units that provide the same internal space as today's units but are 8 in. narrower externally. The redesign includes the option of a foldable wall between two modules, providing access for a disabled passenger and an assistant. Boeing is also developing noise-damping modifications to reduce cabin sound by up to 2.5 db, full cabin-length LED lighting and a 787-style entryway around Door 2.

How High?

As they ratchet up production, Airbus and Boeing wave off concerns about an order bubble

Joseph C. Anselmo and Guy Norris Phoenix

John Leahy, Airbus's chief salesman, and Randy Tinseth, his counterpart at Boeing, do not agree on much, but they are largely in sync when it comes to robust commercial aircraft projections. Leahy, whose company is sitting on a backlog of nearly 6,400 jets, says demand can comfortably support production of 50 A320 narrowbody jets per month and "perhaps even above 60. . . . We don't think, at least through 2020, there's any bubble."

Boeing acknowledges its Renton, Washington, factory could support a monthly output of more than 60 737s, if warranted. Boeing's backlog: 5,790 jets, of which the majority are 737 Next Generation and the 737 MAX follow-on family. "Bubble? What bubble?" he asked on March 9 at the International Society of Transport Air Trading (Istat) Americas 2015 conference in Phoenix. "Everything tells us that demand is strong in the market."

For now, Airbus's plans call for A320 production to reach 50 per month by early 2017, up from 42 currently, while Boeing aims to take 737 output to 52 per month in 2018, up from 42 now. But Airbus's recent revelation that it is looking at taking A320 production to 60 or more per month—and Leahy's apparent bullish support—is beginning to make some industry veterans nervous.

Steven Udvar-Hazy, chairman/CEO of aircraft lessor Air Lease Corp., voiced some doubts. He believes the massive backlogs at the two dominant airframers are not as solid as they once were, citing orders placed by over-ambitious low-cost carriers and struggling airlines in markets such as Russia and Indonesia. "The cushion is beginning to wear off," Hazy says. "[Some] little segments of the backlog are not as golden as they were 12 months ago."

Another prominent aircraft lessor, CIT Transportation & International Finance President Jeff Knittel, says Airbus and Boeing "are in as good a position as I've seen in a long time," with product strategies in place and "a predictable stream of orders." But even he believes the idea of taking A320 production up to 60 a month may be a reach. "If I had a vote, I would suggest they go slow," he says.

Skeptics have warned for years that robust demand for new airliners—which was bolstered by high oil prices and low interest rates—could not last forever. But Airbus and Boeing sailed through the global economic downturn of 2008-09, thanks to overbooking, the strategy of taking more orders than they could fill in anticipation that some of those sales would fall through.

Still, with Airbus and Boeing planning to increase output of narrowbodies by 20% between 2014-18, on top of a 40% increase seen in 2010-14, questions persist about whether they are on a path to produce more aircraft than the market can absorb. Bank of America Merrill Lynch says an analysis of the two manufacturers' announced production increases suggests the global fleet of in-service airline seats will grow 7% annually, "while global traffic may only grow at about 5%." Meanwhile, a drop in crude oil prices from more than $100 a barrel last summer to about $50 per barrel has made it less imperative for airlines to replace older, gas-guzzling models. Merrill's analysts say aircraft retirement levels are down 34% from a year ago.

Knittel agrees there is less urgency now to park older aircraft. But with orders for large aircraft placed years in advance, he is confident demand from airlines and lessors is not about to evaporate. Not many "CEOs [are willing] to bet their company that oil is going to stay at $50-60 a barrel," he says.

AirCap CEO Aengus Kelly concurs that if production rates are raised further the demand will be there. Boeing and Airbus "have a tremendous record of matching supply and demand," he said during an Istat lessor panel. "We have never seen dozens of whitetails sitting in Seattle or Toulouse."

But Norman Liu, president/CEO of GE Capital Aviation Services, appears less enthusiastic. "That's a lot of aircraft," he said. "I just hope these scenarios play out."

Frozen Four

NASA readies for new phase of exploration of dwarf planets and ice-bound moons

Guy Norris Los Angeles

In recent times the search for extraterrestrial life—or conditions that might once have supported it—has focused largely on Mars. But as of early in March, NASA's exploratory gaze is extending to a series of icy worlds in the farther reaches of the Solar System that may not only harbor life but whose characteristics could help explain its development on Earth.

In what NASA's Jet Propulsion Laboratory has dubbed "the year of the icy world," the agency will see three separate spacecraft begin the unprecedented exploration of dwarf planets and a moon over a period of just eight months. While these missions are underway, NASA is also firming up plans for Europa Clipper, a robotic exploration of the Jovian moon Europa, which early in February effectively moved from concept to mission status under the agency's latest budget announcement.

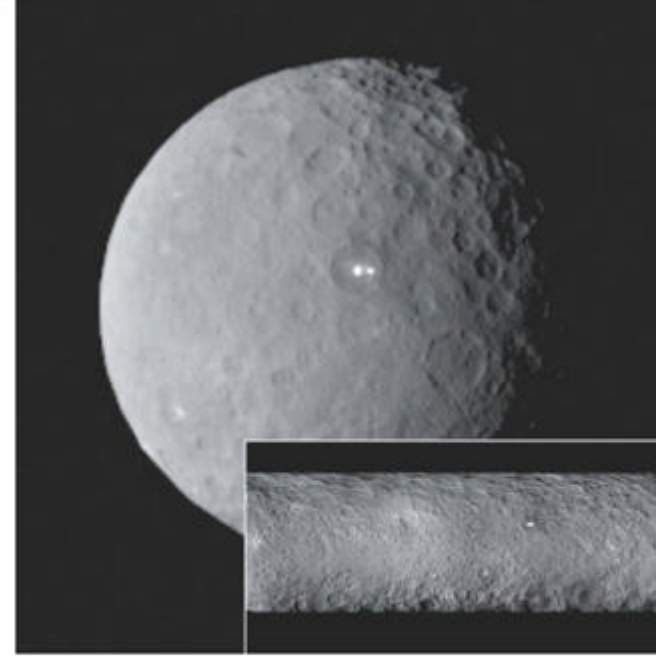
"We are about to embark on an amazing year of discovery and exploration," says JPL senior research scientist and technical manager Bonnie Buratti. "One of the greatest questions NASA is trying to answer right now is 'Where did life come from and how did it originate on the Earth?' The icy worlds that we are [preparing] to explore this year are going to help answer that question."

NASA's Dawn mission, the first to begin this frozen odyssey, arrived at 12.39 UTC on March 6 at Ceres, a dwarf planet in the asteroid belt between Mars and Jupiter, and the largest unexplored world of the inner Solar System. "Dawn delivers big science on a small budget," says project manager Robert Mase. "It's a 'two for one' mission because we also explored the protoplanet Vesta a year ago on the way to Ceres," he adds.

Dawn is therefore chalking up plenty of firsts. It is the first spacecraft ever to orbit two different worlds in deep space, the first mission ever to go to a main belt asteroid and the first to reach a dwarf planet. "The reason they are interesting is these aren't chunks of rock, they're baby planets which started to form like Earth," says Mase. "However, because Jupiter kept stirring the gravitational pot, it wouldn't allow them to form so they stayed small. But they still have a core, a mantle and a crust. They are like time capsules, frozen in time, representing the earliest epochs of the formation of the Solar System."

Even before it reached Ceres, Dawn was already making news. On Feb. 19, when the Orbital Sciences-built craft was still 29,000 mi. from its target, the framing cameras provided by the Max Planck Institute sent back intriguing images of two bright spots on the surface of Ceres. Initially speculated to be icy cryo-volcanoes, Dawn deputy principal investigator Carol Raymond says more recent images show the spots emanate from the center and side of a 92-km (57-mi.-wide) impact crater at the 19 deg. N. Lat. which does not appear to have a mound or other surface features associated with the vent of a cryo-volcano.

"These spots were extremely surprising to the team and puzzling to everyone who has seen them. Their apparent brightness is off the scale," she adds. Raymond says the impact crater may have resulted in the exposure of overlying ice and perhaps "we are seeing deposits left behind by salts. It is a feature that is unique in the Solar System and it's got us on the edge of our seats."



NASA-JPL

Mysterious bright spots, captured in this Feb. 19 main image and early March inset photo of the cratered surface of Ceres, have sparked wider interest in Dawn's science mission, which begins in April.

Carefully steering toward its target using an ion propulsion system, the spacecraft is on track to enter its first science orbit in April and continue through July 2016. Its observations should help confirm suspicions that the 590-mi.-wide Ceres is approximately 30% water by mass. "We expect some icy caps," says Raymond who adds that there is "evidence of active processes going on which are releasing water vapor into a tenuous atmosphere. We might see that we have tens to hundreds of kilometers of ice sitting on top of a hydrated core." There is even the possibility that "we may have a layer of liquid water in equatorial regions."

Studying Ceres in this detail may also help scientists test theories about how the Earth got its water. "We are hoping to understand its geological history, test the hypothesis of its evolution and understand its place in a region that is rich in wet asteroids and main belt comets," says Raymond. "By understanding the nature of these bodies and the impact flux, we might know how many of these objects would have rained in on the inner Solar System at the time the inner planets were forming. That would give us some ideas about the role they played in bringing water to our Earth."

Dawn's ion propulsion system, which is being used for only the second time on a NASA mission after an initial trial on Deep Space 1 in 2001, has been a key enabler to fulfilling the mission objectives. This comes despite the failure of two of the spacecraft's four position-keeping reaction wheels since its launch in 2007. "Ion propulsion is 10 times more efficient than chemical propulsion," says Mase. "The Dawn mission would be difficult, if not impossible, without this technology," he adds.

Power collected from Dawn's 65-ft.-span solar arrays is converted into electricity which is used to ionize xenon, and then accelerate the ions to generate thrust. "We launched in 2007 with 937 lb. of xenon, which is about 71 gal., and we've used 64 gal. so we only have a little bit left," says Dawn chief engineer Marc Rayman. Configured with three ion engines, Dawn

consumes 1 lb. of propellant every four days with the propulsion system active. This means by the time Dawn arrives in orbit NASA expects around 50 lb. to be remaining in the tanks. Following completion of the mission, around June 2016, Dawn "may continue to operate for a few months beyond that but will run out of conventional propellant (hydrazine), so it won't be able to point its solar arrays at the Sun, or its antennas at Earth or instruments at the surface. So it will just die," he adds.

NEW HORIZON'S PLUTO FLYBY

As Dawn slowly spirals down to a closer orbit of Ceres, in another part of the Solar System NASA's New Horizons mission will be approaching its close encounter with Pluto, an event scheduled for July 14. Launched in 2006, New Horizons, the Johns Hopkins University Applied Physics Laboratory-managed mission is the first reconnaissance of Pluto, its moons and the Kuiper Belt. "When we launched the New Horizons mission Pluto was still a planet," says Buratti. "Since then it has been demoted to a dwarf planet but it is one of the biggest objects, if not the biggest object, in the Kuiper Belt, which is formed of hundreds of thousands of ice balls in outer space that were left over from the formation of the Solar System."

With the spacecraft nearing the finale of its more than 3-billion-mi. voyage from Earth, mission navigators are preparing to command the first of a series of course-correction maneuvers as it closes in on the Pluto system. Navigational changes will be based on analysis of the orbital dynamics of the moons around Pluto using pictures captured by the spacecraft's telescopic Long-Range Reconnaissance Imager (Lorri). The aim is to flyby within 6,000 mi. of Pluto, inside the orbit of its largest moon, Charon. "Pluto has at least five moons and we hope to find some more," says Buratti.

Lorri will scan and map Pluto's far side and provide high-resolution geologic data. "We are going to get a resolution of 100 ft. on the surface. If there was a Central Park on Pluto, we'd be able to see it," says Buratti. "We also have spectrometers to look at the surface composition," she adds, referring to the Alice ultraviolet and Ralph visible/infrared imager and spectrometers.

The spacecraft's science instrument suite also includes a solar-wind-and-plasma spectrometer to measure the "escape rate" of the tenuous atmosphere as well as Pluto's interaction with the solar wind. Yet another spectrometer will assess the nature of plasma (ions) escaping the atmosphere; an instrument built by University of Colorado students will measure space dust concentrations at the inner reaches of the Kuiper Belt.

"It is a planet to us," says Buratti. "But the big question we are going to answer is whether it is geologically active or not." Following its six-month transit through the Pluto system, the spacecraft will be directed to survey other icy targets in the Kuiper Belt. From a U.S. perspective, New Horizons also marks another key milestone in space exploration. The U.S. has been the first to reach every planet—Mercury to Neptune—with a spacecraft and, assuming a successful encounter in July, the New Horizons mission effectively completes NASA's initial reconnaissance of the Solar System.

WIKIMEDIA

Dawn

MISSION: Exploring two of the largest protoplanets, Ceres and Vesta, to determine the role of size and water in how planets evolve.

TYPE: Orbiter

STATUS: Current

LAUNCH DATE: Sept. 27, 2007

DIMENSIONS: 1.64 meters (5.4 ft.) high, 1.27 meters (4.1 ft.) long and 1.77 meters (5.8 ft) wide. With solar arrays extended, it is about 19.7 meters (65 ft.) long

WEIGHT: 747.1 kg (1,647.1 lb.) dry; 1,217.7 kg (2,684.6 lb.) fueled

SCIENCE INSTRUMENTS: Framing camera, visible and infrared spectrometer, gamma ray and neutron detector and audio tracker to measure gravitational fields.

WIKIMEDIA

New Horizons

MISSION: The first study of Pluto, the Kuiper Belt and the far reaches of the Solar System.

TYPE: Flyby

STATUS: Current

LAUNCH DATE: Jan. 19, 2006

DIMENSIONS: 0.7 meters (27 in.) high, 2.1 meters (83 in.) long and 2.7 meters (108 in.) at its widest

WEIGHT: 478 kg (1,054 lb.) at launch

SCIENCE INSTRUMENTS: Visible and infrared imager/spectrometer (Ralph); ultraviolet imaging spectrometer (Alice); radio science experiment for studying atmospheres (REX); telescopic camera (Lorri); solar wind and plasma spectrometer (SWAP); energetic particle spectrometer (Pepssi) and space dust counter (SDC).

CASSINI'S GRAND FINALE

After Pluto, NASA's third encounter with an icy world is scheduled to come around three months later in 2015. when the redoubtable spacecraft, Cassini, will make the first of a series of close flybys of Saturn's moons Enceladus and Dione. The first pass of Enceladus will occur close to the 18th anniversary of Cassini's launch in October 1997, and marks the start of the final phase of the spacecraft's mission, which is set to end with a plunge into Saturn's atmosphere in 2017.

"There will be three close flybys of Enceladus this year, the last one coming to within 30 mi. of the surface," says Cassini project scientist Linda Spilker. The craft will be directed to fly through the giant plume of icy particles and water vapor emanating from a series of gargantuan surface fractures near the south pole, dubbed the Tiger Stripes. "Some escapes Enceladus's gravity and creates the E-ring around Saturn," she adds. Saturn has seven main rings which are labeled in the order in which they were discovered. From the planet outward they are D, C, B, A, F, G and E, the latter extending outward 620,000 mi. from Mimas inside the orbit of Enceladus all the way to the orbit of Titan.

"We will be 'tasting the plumes' and sampling them. The largest icy particles are salts, and according to cosmic dust analyzer, are mostly sodium chloride and potassium. So we know now that the liquid water ocean under the crust at Enceladus is in contact with the rocky core," says Spilker. "We found organics like carbon dioxide and nitrogen, so we know that the ocean of Enceladus harbors the

ingredients for life." The flight through the plume itself is not expected to jeopardize Cassini. "We've flown through plumes and, so far, it has been fine. The density of particles hasn't been enough to make us worry about the spacecraft," Spilker says.

The science team hopes to get better views of Enceladus's north pole on other flybys. "It turns out when Cassini first arrived, the north pole was in darkness; now we can get a good look it after 10 years in orbit around Saturn. With the seasons changing we're coming close to the summer solstice, so we can get a high-resolution look at the north pole and perhaps [discover why just] the south pole is active. Maybe the north was active, too. So we will be looking for evidence of fractures and on the final flyby will go back to the south pole where it is all dark now. We're going to make a thermal map to see how much heat is coming out of the Tiger Stripes."

Two more flybys will also be made over the moon Dione, which measures around 700 mi. across. "We thought there had been some kind of cryptovolcanism but now we are looking at large canyons with icy walls on the sides, so it does not appear to be that," says Spilker. Readings from Cassini's magnetic field instrument, however, do indicate some level of activity. "That was the first clue that caused us to go closer to Enceladus, and Dione has the same thing but is much weaker. We wondered if there could be activity at a lower level, so on one of these flybys we will use the ion and neutral mass spectrometer (INMS) to sniff them out and see if there is any evidence for material coming out of Dione. We will also [take] more gravity measurements [to see if] it too could have water under its icy crust."

However, for Cassini time is running out. "The gas tank is on empty and we have just enough to get us through to the end of the mission in 2017," says Spilker. "We found a way to jump across Saturn's huge rings and actually orbit inside the inner ring, so we have 22 orbits that will go into this area. It is like a brand-new mission to see a place we haven't seen before. We will find out for the first time the planet's gravity field, its magnetic field and the mass of the rings." During 2016 and 2017 the orbits will "go up and over the north and south poles of the planet, and Cassini will actually dive between the innermost edge of the D ring and the upper edge of the atmosphere itself," she adds.

WIKIMEDIA

Cassini

MISSION Exploring Saturn, its moons and its rings.

TYPE: Orbiter

STATUS: On its second, extended mission

LAUNCH DATE: Oct. 15, 1997

DIMENSIONS: 6.7 meters (22 ft.) high and 4 meters (13.1 ft.) wide

WEIGHT: 5,712 kg (12,593 lb.) with fuel, Huygens probe, adapter, etc.; 2,125 kg (4,685 lb.) unfueled orbiter alone

SCIENCE INSTRUMENTS: Composite infrared spectrometer, imaging system, ultraviolet imaging spectrograph, visual and infrared mapping spectrometer, imaging radar, radio science, plasma spectrometer, cosmic dust analyzer, ion and neutral mass spectrometer (INMS), magnetometer, magnetospheric imaging instrument, radio and plasma wave science.

NASA JPL-CALTECH

Europa Clipper

MISSION: NASA is studying whether to conduct detailed reconnaissance of Jupiter's moon Europa, and whether the icy moon could harbor conditions suitable for life.

TYPE: Orbiter

STATUS: Proposed

LAUNCH DATE: To be determined.

MAKING PLANS FOR EUROPA

Plans are meanwhile firming up for the Europa Clipper, a proposed new NASA flagship project that aims to explore this mysterious Jovian moon next decade says JPL Deputy Director Gen. Larry James. "We will have the official kickoff of that mission this spring when we have the key decision point "A" at NASA headquarters, which will give us the formal approval to start considering how we would formulate the mission," he says. The April meeting will also include baseline selection of a sensor suite for the mission, which JPL is proposing as a flyby of Europa in order to handle the hazardous Jovian radiation environment and avoid the cost and complexity of a massively radiation-hardened orbiter.

"The mission will perform reconnaissance to pave the way for future landings," says JPL senior research scientist Robert Pappalardo. "After 15 years of studying mission concepts for Europa we believe we now have the one that is just right. We orbit Jupiter, making many flybys, and if we spot a plume we can sail right through them to taste Europa's innards." The spacecraft will "effectively obtain global coverage from 45 flybys over three years [similar to the way] Cassini mapped out Titan. A Jupiter orbiter offers the best science for an optimal cost."

"We want to confirm the existence of the ocean and we can do it with magnetic instruments and by measuring the flex of the [icy] shell by flying by at different times," says Pappalardo. "We want to understand how thick the shell is and understand the composition of the reddish stuff on the surface. Does it contain organic molecules, does it contains salts? We want to understand the circulation in that ice shell." Scientists postulate that chemical nutrients created at Europa's surface by radiation levels that would kill a human in 20 min., could filter down into the subsurface ocean and serve as a fuel for life.

The radiation is so intense on Europa because of Jupiter's powerful magnetic field. Rotating every 10 hr. relative to Europa, the magnetic field accelerates high-energy particles which bombard the moon so intensely it colors the icy mantle. Protecting the spacecraft systems will be tackled by placing the Clipper in a highly elliptical orbit, thereby reducing overall exposure levels, and by housing sensitive instruments in a shielded "vault." "Inside are all the electronics we want to protect," says JPL Europa Clipper project engineer Sara Susca. The main platform of the proposed spacecraft will be around 18 ft. tall and, when combined with solar panels, "will be quite big," Susca adds. "It will have two large solar panels both about 29 X 4 ft."

Tilt to the Future

Tiltrotors could streamline oil and gas operations

Tony Osborne **Orlando, Florida**

While the military need for high-speed rotorcraft is widely accepted, the introduction of such a capability for the commercial market has been seen as a bit of a folly, at least until now.

As the one of the world's largest commercial helicopter operators, Bristow Group's decision to support AgustaWestland's tiltrotor program is a major turning point for high-speed rotorcraft. It will not only transform the shape of oil and gas exploration support operations but deliver a considerable boost to the Anglo-Italian manufacturer's development of the AW609.

AGUSTAWESTLAND

Bristow sees AgustaWestland's tiltrotor aircraft playing a multi-faceted role in its future.

The signing of a joint development agreement between the two companies at Heli-Expo on March 3 will allow Bristow to exclusively direct the shape of the tiltrotor for offshore missions such as oil and gas operations. The changes could extend beyond the AW609 to potentially affect the design of larger and more advanced models that AgustaWestland is planning to introduce in the early 2020s.

The realities of offshore transport are changing; offshore operators are placing greater emphasis on longer-range rotorcraft. This is not just because their clients need to fly farther offshore but also because they want to be able to reduce their costs by picking up workers closer to where they live.

Currently, all across the world, oil companies must fly employees—often by fixed-wing transport—to remote airfields, where they transfer to a helicopter in what the traditional airline world would describe as a hub-and-spoke operation.

Energy companies are striving to reduce their overall costs, and Bristow believes it has to bring in new technology to accommodate this need.

The evolution is underway with Bristow's purchase of two regional airlines, Eastern Airways in the U.K. in early 2014 and Airnorth, an Australian carrier, in February. By adding these two airlines, Bristow gains not only considerable fixed-wing experience but now can link its rotary- and fixed-wing services to offer seamless service to clients under a single contract.

A similar operation already exists in the U.K. The Integrated Aviation Consortium (IAC) oversees flights of oil workers on Eastern Airways aircraft from Aberdeen, Scotland, to Scatsta in the Shetland Islands, where they then board a fleet of Sikorsky S-92s for platforms offshore.

The introduction of tiltrotors would allow for point-to-point operations, eliminating those remote sites, and flying personnel to platforms from major population centers, says Bristow President Jonathan Baliff. Tiltrotor helicopters can generally transport passengers above the weather in relative comfort with a greater margin of safety.

"We see tremendous opportunities for this aircraft for our clients who are flying to more remote and hostile environments," says Baliff.

"It is a unique opportunity to work with an operator with combined rotary- and fixed-wing [experience]," AgustaWestland CEO Daniele Romiti tells Aviation Week. "Having Bristow [supporting the project] brings solidity to a market that perhaps saw us as a bit too enthusiastic. But now it is proven fact that this is about a real market rather than a virtual one."

Baliff says the AW609 could prove useful for high-speed medevac missions, transporting injured or sick personnel to hospitals on the mainland in half the time of a helicopter. Tiltrotors could also ably handle search-and-rescue services that Bristow operates for the U.K. government, as well as for some oil and gas clients.

Bristow will advise AgustaWestland on the concept of operations, regulations, maintenance and configuration optimization as well as identifying areas for enhancement or modification preparing the tiltrotor for operations over water and onto oil and gas platforms.

AW609 program manager Clive Scott described the deal as an extension of a maintenance review board—a process followed by a manufacturer and an operator during the certification of a new type.

"We have a lot of experience with oil and gas helicopters, but we don't have experience on fixed-wing operations, so Bristow's experience will be invaluable," says Scott.

Bristow has long had an interest in the development of the commercial tiltrotor, from when Bell and Agusta jointly displayed early mockups in the late 1990s. As part of the new agreement, Bristow test pilots have flown one of the prototypes, and additional workstreams between the two parties are being prepared.

Meanwhile, AgustaWestland is well underway toward beginning AW609 production, with the announcement that there will be two assembly lines, at the company's U.S. facility in Philadelphia and in Italy at the company's Vergiate plant, near Milan.

The fourth prototype, AC4, which will feature many production-standard elements including the new Rockwell Collins Fusion avionics suite, has been transported to Philadelphia for assembly in 2016. The third prototype, AC3, has been built in Italy and will take part in deicing trials in the U.S. later this year.

Bang Per Yuan

Reports of China's military budget are inflated, but spending may become more efficient

Bradley Perrett Beijing

In what has become an annual tradition, media reports are exaggerating the rise in the Chinese defense budget, omitting adjustment for inflation. But now there is another, contrary adjustment that no one can ascertain with any precision: The anticorruption crackdown of President Xi Jinping must be making that spending more efficient. Compared with two years ago, China should now be getting more bang for its yuan but fewer sumptuous dinners and luxury cars.

Beijing says it will spend 10.1% more on defense in 2015 than last year. The government expects consumer prices to be about 3% higher this year, so the planned rise in the real defense budget should be close to 6.9%—though other measures of price changes, such as the gross domestic product (GDP) deflator, would give a slightly different result.

Since Premier Li Keqiang forecasts GDP adjusted for inflation will be about 7% higher in 2015 than 2014, China is planning barely any change in its official defense budget as a fraction of the economy. This contrasts with widespread reports that, by growing 10.1%, the defense budget is advancing faster than the economy. Media often forget to factor in the effect of inflation on the Chinese defense budget.

YAN SIMING/INTERNATIONAL AVIATION

Chinese military equipment, such as the Avic KJ-200 radar aircraft, is rapidly becoming more sophisticated.

In 2014 defense spending, nominally 12.2% higher than a year earlier, was up 9.7% after adjustment for inflation, calculates analyst Roger Cliff of the think tank Atlantic Council. So in that year defense spending did rise faster than GDP, which advanced 7.4%.

But from 2009 to 2015, the inflation-adjusted official defense budget has grown at an average of 6.9% a year, compared with 8.2% average economic growth, says Cliff. China announced its official 2015 defense budget, 886.9 billion yuan ($141.68 billion), on March 5.

However, all of these figures create a false impression of precision, because much of China's military spending is not in the official defense budget. Many countries do this, creating a widespread problem in analyzing and comparing defense budgets.

Including spending not in the defense budget, China allocated 2-2.2% of GDP to its military from 2001-13, tending to the lower end of the range since 2009, estimates the Stockholm International Peace Research Institute. Cliff's calculations agree with that, showing the official component trending down as a fraction of GDP over the past six years.

A further complication in any assessment of China's military effort is that the economy may not be growing as fast as the government has been saying. The 7.4% rise in GDP posted for 2014 was far from the 10% commonly seen in the three decades from the late 1970s, when the economy began opening. But some economists, pointing to such indicators as energy consumption, suspect that the rate of Chinese economic expansion has slowed to 6%, or even less.

Whatever the relationship to GDP, the Chinese military is probably now spending its defense budget more efficiently, because of the president's crackdown on corruption. Money that was formerly embezzled or spent on lavish benefits for service personnel should now be available for enhancing military capabilities. Three days before the defense budget was announced, military prosecutors said 14 generals had been convicted of or were under investigation for corruption.

"The General Logistics Department should find greater capital freed up which might have been embezzled," says Alexander Neill of the International Institute for Strategic Studies in Singapore. Since it handles supplies, the logistics organization has been highly susceptible to embezzlement. Chinese contractors will often pay kickbacks to officials who control orders.

The military effects of the anticorruption crackdown will be complex, however. To the extent that famously attractive fringe benefits have been curtailed, attracting talented people into the armed forces could prove to be more difficult. But the average recruit to the officer corps may now be a good deal more interested in serving his or her country than in building a network of connections with the aim of personal profit. And those who have hitherto spent their careers feathering their nests are probably now, like government employees across China, paying more attention to their jobs, or at least going through the motions of doing so.

Neill expects that cleaning up corruption will allow the Chinese military to direct benefits to personnel more rationally and efficiently. "I would imagine that any money that is freed up will be recycled into salaries and manpower," he says.

Senior defense ministry officials have told him that recruitment and retention are key challenges. In particular, the armed forces are rapidly rising in sophistication, but need more technically trained recruits to operate and maintain the new systems. The challenge applies to filling the ranks with technically adept noncommissioned officers, too. Already, the Chinese military is offering higher pay for people with the right skills.

United Front?

Merged carrier faces safety pressures in the midst of retirements, recalls and new hires

John Croft Washington

An alert from top United Airlines safety officials is raising concerns about safety culture at the third-largest airline in the U.S. downstream of its merger with Continental Airlines in 2010 and an increasing number of retirements due to the "Age 65 Law."

Concerns are not limited to United, given the broader landscape of consolidation within the U.S. airline industry that forces the coming together of dissimilar operational and training cultures. This merging coincides with a large number of new hires to replace the more than 18,000 pilots reaching the age-65 limit in the next seven years. American Airlines is facing a similar integration with US Airways pilots, as does Southwest Airlines as it brings AirTran Airways pilots into the fold.

A bulletin issued Jan. 9 by United's senior vice president of flight operations, Howard Attarian, and vice president of corporate safety, Mike Quiello, discusses "major safety events" and "near-misses" in the "past few weeks." Included are two events "in close proximity" to terrain, one that resulted in a ground proximity warning system (GPWS) "pull-up" command, one "undesired aircraft state" on departure and a low-fuel state on arrival at Los Angeles International Airport. Attarian, a former U.S. Air Force Thunderbird pilot, is responsible in part for overseeing training and flight standards and the airline's FAA operating certificate. Quiello is a former U.S. Marines pilot who held the top safety role at Delta Air Lines before coming to United in 2009.

"We are currently seeing a lot of movement in the pilot group, such as retirements, seat movements and new hires, that—while welcome—introduces significant risk to the operation," the bulletin states, adding that United is at a critical juncture and its pilots must follow the policies and procedures.

United has not answered questions on the seriousness of three of the incidents, but according to airline documents obtained by Aviation Week, the low-fuel event took place when a Boeing 737-900 flying from Washington Dulles International to Los Angeles landed with less than the required 45 min. of reserve fuel after it changed its route and the airport switched from an "east flow" to a longer west flow during the arrival. The pilots had declared "minimum fuel" state with the air route traffic control center.

Once leaked, Attarian's internal memo raised doubts about what had largely been regarded by the public as a sterling safety record at the carrier. In terms of incidents investigated by the NTSB in the past few years, most have been due to turbulence. As to how often GPWS alerts occur, NASA's Aviation Safety Reporting System (ASRS) lists more than 50 U.S. air carrier incidents in 2014. The GPWS alerts in the de-identified reports, voluntarily submitted by pilots, in some cases are linked to an approach to terrain and in other cases occur due to improper configuration of the aircraft. Airlines often directly learn of the incidents via non-punitive pilot reporting programs or a flight operations quality assurance program, which includes a downloading and review of flight data. Most of the ASRS incidents did not appear to have jeopardized safety.

A Feb. 19 letter from Bob Sisk, the Central Air Safety Committee chairman for the United pilots union, part of the Air Line Pilots Association, expanded on Attarian's bulletin. Sisk lists six common threads in a number of "serious situations" or "near-misses" that he says United has experienced over the past two years, including these key four:

- The captain was generally highly experienced in the fleet type.
- The first officer was a new hire, a returning "furloughee" or was relatively new on the fleet.
- There was a lack of crew resource management (CRM) intervention, "although there was discomfort with the developing situation."
- Pilots did not typically brief together as a crew.

Sisk says "numerous pilots have reported significant discrepancies between how standard operating procedures (SOP) are presented in training and how they are implemented on the line," which is a "deep concern" that could be a contributing factor in "many" of the incidents.

United has recalled most of the 1,500 pilots that were furloughed in 2008-09 and is planning to hire about 800 new pilots this year. That intake of personnel will likely continue, as the carrier is forecasting that 11,000 pilots will retire between now and 2039, roughly the equivalent of its entire pilot workforce.

The carrier has not said how it might address the immediate concerns beyond a plea by Attarian for pilots to review, understand and comply with guidance in company manuals.

Leaders of the union shop representing United's Chicago O'Hare International hub question management's sincerity. "The hard truth is that management is destroying the type of positive safety culture which was once alive at this company," the pilot leaders say in a notice to members. "Management is embracing a culture in which economics and schedule is placed above safety, the science of flight and the law."

The merging of dissimilar flight departments in terms of the experience, training or proficiency of pilots can be a "leading indicator" for increased safety risks.

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Last Chance

Under new leadership Air Berlin is attempting to regain profitability, but more support from shareholder Etihad may be needed

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Air Berlin sees more potential to grow its long-haul business, which is based on an all-Airbus A330 fleet.

Jens Flottau Berlin

Germany's second-largest airline, Air Berlin, has been ailing for years, thanks to a toxic mix of mismanagement at the top and divergent shareholder interests. Now it is pinning its hopes on new CEO Stefan Pichler to right this situation. But does he have the skills and time needed?

The new CEO held important positions in Germany's airline industry more than 10 years ago. He led Lufthansa's sales division and then ran leisure group Thomas Cook, but was fired when losses mounted. His next several jobs in the last decade were for airlines outside of Europe, notably Virgin Australia Airlines, Jazeera Airways and Fiji Airways.

"It is a real joke that I am the fourth CEO in three years," says Pichler, referring to the dismal state of Air Berlin's previous management. Important decisions were not taken because of the constant leadership changes, he says, which delayed crucial strategy shifts. Pichler made these remarks during his first public appearance in his new role.

Air Berlin expanded aggressively after its 2006 initial public offering, evolving from a charter operation into a scheduled airline. It also acquired two small German airlines, DBA and LTU, although it never fully integrated them. Even though the carrier later joined the Oneworld alliance, it only narrowly avoided bankruptcy, thanks to Etihad Airways' purchase of a 29.2% stake in January 2012. Etihad has since provided additional much-needed financial assistance. Competitors claim the German carrier is effectively under the control of a non-European investor, which is illegal; Air Berlin and Etihad strongly dispute this. Pichler says no additional Etihad funding is planned, but his statement did not outright rule out more financial assistance to support the turnaround. He aims to achieve an operating profit in 2016.

The carriers face a strategic dilemma. Etihad is interested in European feed for its own long-haul flights, but the European component is the worst-performing part of the Air Berlin network. Although its leisure network to Mediterranean destinations is healthier, it is of little strategic value to Etihad.

Conceding that he does not have a detailed strategy in place a few weeks after taking on the job, Pichler says Air Berlin's main problem is low unit revenue. In the third quarter of 2014, the airline's average revenue per passenger was €119.4 ($132), a reduction of 4.4%. The drop came as it recorded a very high 87% load factor, indicating that it has been trying to fill overcapacity by lowering fares below a profitable level.

Air Berlin is now making even more cuts to its March-June capacity, taking 5% of seats off the market, an equivalent of seven aircraft. Additional cuts could follow when a more detailed per-route profitability analysis has been completed. Pichler wants to focus on markets where Air Berlin is strong and pull out of areas where it has less market share. One key concern is that even at its major hubs in Berlin and Dusseldorf, the airline has a market share of only 35% and 33%, respectively. Pichler says he sees growth opportunities in the long-haul market but did not specify where.

The airline is reinstating a lower fare for passengers with no checked bags. This option had been dropped in mid-2014. Fare rates to attract corporate clients are being pursued. More flexibility to rebook could be accorded to less-expensive classes if they are covered by a contract with large corporations.

With Pichler now at the helm, others are leaving the executive board. Long-time CFO Ulf Huettmeyer has been hired by Etihad for a senior finance role, a move decided long before the new CEO joined. And in late February, Air Berlin's former CEO, Wolfgang Prock-Schauer, announced his immediate departure as chief strategy and planning officer; he had served in that capacity for one month following his demotion.

The most important short-term relief to Air Berlin came on March 2, when Germany's civil aviation authority Luftfahrtbundesamt (LBA) approved codesharing services between it and its partner Etihad for the upcoming summer period. The decision, which surprised many industry analysts, was made after months of uncertainty about whether the two airlines would to be able to continue to cooperate on flights from Abu Dhabi to Berlin and beyond, to destinations in Germany, other European countries and across the Atlantic. The approval for 34 codesharing services must be renewed for the winter. Industry sources in Berlin caution that the LBA extension is not a permanent solution.

The decision allows Germany and the United Arab Emirates (UAE) more time to resolve their disagreement about the interpretation of the bilateral air service agreement or to negotiate a new one without damaging Air Berlin/Etihad business in the near term. The LBA had approved the codesharing deal for six periods up until mid-2014, but then said codesharing is not covered by the bilateral pact, arguing that the contract would only allow cooperation on three domestic routes in Germany. The UAE, Air Berlin and Etihad are disputing this.

LBA last fall first revoked, then reinstated, its approval to allow more time for talks, even though the German transport ministry insists there is no basis for the joint flights in the current bilateral agreement. Lufthansa and leisure airline Condor have been lobbying hard against the Etihad/Air Berlin alliance. Lufthansa is said to be considering legal action.

The outcome is far from clear; the ministry could insist on its current interpretation—LBA is a subordinate authority. If so, codesharing would not be allowed in the next winter timetable, undermining the basis of Etihad's 29% investment in Air Berlin.

Starting From Scratch

Remote Atlantic island set to pick flight operator for its first airport

Tony Osborne London

Early next year, aviation will help change life on the remote British outpost of St. Helena.

For decades, the routine on the South Atlantic island has been on a three-week cycle, dependent on the comings and goings of a mail ship, the RMS St. Helena that brings supplies and visitors from Cape Town, South Africa.

But the opening of the island's first airport in early 2016—at a cost of £201.5 million ($300.2 million) financed by the British government—will open St. Helena to tourism and, it hopes, set the island on a course to self-sustainability.

In preparation for the airport's opening, the island's government is expected to announce by the end of March the winning proposal for a subsidized weekly flight using a 120-seat aircraft. The operation would connect the island with a hub such as Cape Town or Johannesburg, which are 1,700 and 2,000 nm away, respectively.

"Airlines and operators are now becoming aware there is something happening in the South Atlantic," airport project director Janet Lawrence tells Aviation Week. "There is a growing interest from airlines, and we are regularly receiving requests about the planned price of aviation fuel and the other facilities we have here."

With the opening of the airport, sea access using the RMS St. Helena will terminate in July 2016. Flights to the island from Africa will be subject to 90-min. extended-range operation regulations. The ultimate aim is to make the service sustainable through tourism without the need for subsidies.

It is currently a five-day voyage from Cape Town by ship, and just few thousand tourists are currently able to make the trip each year, arriving on yachts or the cruise ships that occasionally visit the island or on the regular charter ship from Cape Town.

With the establishment of an air service, travel times from the U.K. will be shortened to two days from one week, making a visit more attractive to a wider market. Indeed, the St. Helena government is confident the island can become a niche destination with its year-round equatorial climate and history. According to the proposal documents given to potential flight operators, the number of visitors to the island could almost double in the first year of airport operations, based on conservative estimates of the numbers of tourists, visits from St. Helenians now living abroad and business travelers.

Flights to the airport will be challenging as there are no regular airways that go near the island and the only diversion options in the event of poor weather are a return to the African mainland or continuing to the joint U.S./U.K. facility at Ascension Island, 700 nm to the northeast.

Construction of the airport facilities, runway terminals and ancillary buildings has been relatively straightforward, but preparing the ground for its construction has been a feat. The airport is sited on the east side of the island, on Prosperous Bay Plain, an arid landscape formed by lava flows. South African contractor Basil Read first had to install a dock for its ship in order to deliver the equipment needed for the construction work, before building or rebuilding 40 km of access road to the airport site. In order to get the runway to its full length of 1,850 meters (5,100 ft.)—a declared landing distance of 1,550 meters—engineers had to fill in part of a valley, in a project called the dry gut, which involved moving eight million cubic meters of earth to add to the runway platform. This has resulted in steep sides at the southern end of the runway, necessitating the installation of Runway End Safety Areas.

Once complete, the airport will be able to handle aircraft up to the size of a Boeing 757-200 or Lockheed L-100-30 Hercules, although such aircraft will be payload-restricted on departure.

Emergency facilities are also being strengthened, with the island carrying out its first emergency exercises to test the response to a major incident such as an aircraft accident. The certification process will begin later this year. Air Safety Support International, a subsidiary of the U.K. Civil Aviation Authority, will act as regulator for St. Helena as it does for other U.K. overseas territories. Part of the certification process will include using Honeywell's Smart Path Ground Based Augmentation System, which will allow for a series of curved approach paths to be developed for the airport. The system will be installed during the second quarter of 2015 in time for navigation-aid calibration flights due to take place this coming July.

The calibration aircraft will be the first to land at St. Helena, and the spectacle is likely to be something of a crowd-puller for islanders.

Millions of cubic meters of earth were moved to create a platform for the runway at St. Helena, with the first aircraft due to land this July.

REMI BRUNETON

Making Pace

Larger CSeries test aircraft will also support certification of initial CS100 variant

Graham Warwick Washington

Bombardier's first CS300 has joined a CSeries test program now racking up flights at a rate the manufacturer says keeps the all-new airliner on track for entry into service (EIS) toward the end of this year. Certification of the 135-seat CS300 is expected about six months after approval of the initial 110-seat CS100.

In addition to unique testing required for the stretched variant, two CS300 test aircraft will conduct trials to support certification of the basic design, augmenting flying by five test CS100s and the first production aircraft, which will be used for final FAA function and reliability testing.

The first CS300, flight test vehicle (FTV) 7, made a 4-hr., 58-min. maiden flight from Mirabel, Quebec, on Feb. 27. The aircraft and systems performed as expected, and with no post-flight modifications required, according to Bombardier, the aircraft was back in the air on March 3.

Maintaining a fast pace in flight tests is critical to meeting Bombardier's commitment to begin CS100 deliveries this year after the 100-day grounding that followed the May 2014 uncontained failure of a Pratt & Whitney PW1500G geared turbofan during post-maintenance ground testing.

Testing has passed the 1,000-flight mark and "we've flown 25 hr. already in March, and that's excluding the CS300," Rob Dewar, Bombardier vice president and CSeries general manager, tells Aviation Week.

Initial results suggest Bombardier may be able to reduce the flight testing required to certify the CS300 because of its similarity to the CS100. "We chose to start tests with the longest flights we have so that if the results are favorable relative to the CS100, we can reduce a lot of testing," he says.

"Handling on the first flight was absolutely identical to the 100," Dewar notes, quoting pilot-in-command for the CS300 flight Andy Litavniks, who was co-pilot for the first CS100 flight in September 2013 and has a "couple of hundred hours" on the aircraft. "He did not see any differences, so we may have a smaller test program than we planned," Dewar says.

Since initial results look good, Dewar plans "to put the 300s to work to help out the 100, as many of the systems are identical," he says. "But we will keep the accounting separate, and those tests that are dedicated to the 100 will count against the 100's certification target."

Otherwise, the two test CS300s will focus on those aspects of the aircraft that are different from the CS100. "All the systems are identical part numbers except the brakes, fire extinguishers because of the longer cargo bays, and longer wiring harnesses," says Dewar. The CS300 is 12 ft. longer than the CS100. "The only systems tests required are related to the differences."

They will include cabin temperature pull-down/pull-up and smoke evacuation tests. The second CS300 test aircraft,

FTV8, will be equipped with an interior. "We originally planned passenger evacuation tests but, based on the CS100 tests, we don't think they will be required," he says.

Taking advantage of the work already completed on the CS100, the CS300 entered flight testing in the latest build standard. "We have six build standards, mostly related to software, and FTV7 flew in Build 5, which is EIS-ready," says Dewar, adding the final Build 6 will incorporate any changes that emerge from the remaining tests. One of the CS100s, FTV3, is also at Build 5, along with the first production CSeries, P1, which is off the assembly line in Mirabel and scheduled to fly this summer.

CS300 flight testing has begun with the fly-by-wire flight control system in back-up direct mode, without envelope protection, but will switch to normal mode shortly, says Dewar, adding that CS100 test aircraft always fly in normal mode. "First, we have to go to the more extreme parts of the flight envelope in direct mode, then we can move into normal mode."

pretty good. We are quieter than the Q400." Being as quiet as the Bombardier regional turboprop is critical to at least one CS100 customer, Porter Airlines, which operates out of Toronto's downtown island airport.

With flight tests racking up, attention is turning to entry into service and Dewar holds daily meetings to track reliability and dispatch issues. "It is critical to identify and resolve these in flight test," he says. "The test aircraft are averaging 98.5% dispatch reliability, which is a record for us in flight test."

Ground tests and aircraft upgrades performed while the fleet was grounded last year have helped increase maturity. "The extra four months have helped," admits Dewar. Malmo Aviation stepped down as the planned launch operator of the CS100 last year, citing the potential for further delays, but Bombardier is now "working with a couple of operators" on the pilot and maintenance training, manuals and spares provisioning required for service entry.

The second CS300 test aircraft, FTV8, will fly later this year and focus on testing interior changes from the CS100. The longer CS300 can seat up to 160 passengers.

BOMBARDIER

While FTV1, 3 and 4 were relocated to Wichita to take advantage of better winter weather, the two test CS300s are planned to remain in Mirabel. "We are over the worst of the weather and plan on keeping them here," he says. The final CS100 test aircraft, FTV5, is scheduled to fly this month and will be based at Mirabel. FTV5 is the first CSeries to be equipped with an interior.

As for the CS100, "80% of high-risk tests are completed," says Dewar. "We have finished all stall tests, with and without ice shapes, and meet all stall performance requirements. We have done engine relights—up to 24-26 per flight—with favorable results. We have done evacuation tests, all development tests for the brakes and preliminary noise measurements."

Still ahead is runway performance testing, to confirm minimum unstick speed, which is planned for the spring in Salina, Kansas. Also to come is final certification of the brakes and runway water-ingestion testing. FTV2 has been configured for natural icing tests and Bombardier is waiting for the right conditions. "We are holding schedule. The best time is the fall or the spring, and the best conditions should be toward the end of March and into April. We are ready now," he says.

Aircraft FTV4 has completed cruise performance testing, and results are "on track with or slightly better than" predictions, says Dewar. Test vehicles are usually heavier than production aircraft, but the CSeries FTVs "are in pretty good shape," he notes, adding that "payload/range of the aircraft is better than brochure."

Development tests to measure airport noise show the aircraft "is about 1 dB better than predicted," he says. "Two measurement points are better and one is slightly worse, which is

As for production, Dewar says the CSeries is now being built "in position," as planned, with no traveled work. This includes the three aircraft on the final-assembly line in the new building at Mirabel: second CS300 test aircraft FTV8 and production CS100s P2 and P3. Fuselage work that was moved to Bombardier plants for the initial aircraft is now back in place with SACC in Shenyang, China, he says.

To stabilize the front end of production, Bombardier is building the first block of five production CSeries in a single configuration and the second block of five in a different "but very similar" configuration. However, Dewar says Bombardier has strived for a modular, track-mounted, "plug-and-play" interior configuration to avoid major customization. "All the customers so far are inside the box," he says.

Bombardier in February revealed projected CSeries development costs now total $5.4 billion, up from the original $3.4 billion, in part because of last year's grounding. Dewar says earned value—the credit accrued for hours flown—is slightly ahead of plan. But in the new development cost estimate, "we took a bit of margin—you can imagine there is not a big appetite to go back and ask for more money," he says.

In the face of liquidity concerns caused by higher product development costs and lower free cash flow, the Canadian manufacturer in late February raised $868 million in new equity. This was more than 40% of the $600 million originally outlined under a new financing plan unveiled last month. Bombardier has also announced plans to raise $2.25 billion in new debt, up from the $1.5 billion outlined in early February. Citing the increased liquidity, and progress in CSeries flight testing, analysts have improved their outlook for the company.

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The next issue of the MRO Edition will be dated April 13-26.

Maintenance Manpower Shortage?

Schools were not teaching what we needed students to know.

What is the aerospace industry doing to address the looming shortage of qualified aviation mechanics and engineers? Is activity more focused on words or action?

In an IdeaXchange blog on AviationWeek.com, Brett Levanto, the Aeronautical Repair Station Association's (ARSA) director of operations, stressed: "We've got gaps to fill, but well-trained men and women are taking their talents elsewhere."

He points to an Aviation Technician Education Council (ATEC) survey that shows one-quarter of aviation maintenance training school graduates accept jobs outside the field. Why? Many reasons are cited: everything from wages to more opportunities in other fields that require mechanical and electrical skills.

ARSA and ATEC conducted a study in late 2014 that found the U.S. government supply and demand statistics for the MRO workforce "can't be accurately observed," which makes it tough to ascertain the problem. However, at least in the U.S., inconsistent employment trends exist between regions, the study found.

Haeco Americas (formerly Timco Aviation Services) has tackled the workforce issue locally and achieved great success.

A few years ago, Haeco Americas found that "schools were not teaching what we needed students to know," says Kip Blakely, vice president of industry and government relations. So at the time, Timco, Honda Aircraft and B/E Aerospace formed a local aviation council in Greensboro, North Carolina, and started working with area middle and high schools and community colleges.

Haeco takes a hands-on approach and visits middle schools to help students with geometry problems and to promulgate science, technology, engineering and math education. It engages with aviation academies and charter schools. It is hosting its sixth, five-week job-shadowing program for high school students, with later invitations to their parents to see what kinds of activities their kids perform. By 12th grade, Blakely says, Haeco offers paid internships, after which students attend a community college to gain an associate's degree and an airframe and powerplant (A&P) license. By the time they are 25, they can make $50,000 a year. In 2014, 52 students served as job shadowers, interns or co-ops, and Haeco Americas plans to increase that number this year, says Blakely.

That's laying out a clear message and backing it with action.

If your company works with local A&P schools, see if it is interested in participating in the Aerospace Maintenance Competition, which will be held in conjunction with Aviation Week's big MRO Americas Conference & Exhibition April 14-16 in Miami. It's a great way to engage A&Ps.

Speaking of engagement, when I spoke with AAR Corp. Chairman and CEO David Storch, he stressed that AAR tries hard to provide good opportunities for its workforce. It must succeed because the company has a low employee turnover rate (see page MRO12).

Look at the company's two pillars: innovation and execution—each of which is necessary for success.

—Lee Ann Shay

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

AAR CORP.

AAR's Miami facility is participating in the FAA's SMS pilot program.

Meaningful Metrics

Operators, MROs ramping up data analysis

Sean Broderick Washington

As regulators continue their shift to risk-based oversight driven by data collection and analysis, many operators and maintenance providers are several steps ahead, using data to boost efficiency and spot issues before they become problems.

In the U.S., the FAA gave airlines until March 2018 to implement long-planned safety management systems (SMS), including data monitoring. But most carriers already collect and share data through a Flight Operations Quality Assurance (FOQA) or other flight data monitoring (FDM) system. The real opportunity is leveraging such programs as more than safety-improvement tools, says Raul Segredo, president of avionics supplier Avionica.

"Our customers find good return on investment for FOQA or FDM, regardless of mandates," says Segredo, whose company has sold more than 7,000 quick-access recorders (QAR) that support FDM efforts. "At first it seems like a burden, and the benefits are perhaps not obvious, but once you get it right, you're saving money."

Segredo points to FlyBe as an example. The carrier needs an FDM program to comply with European Aviation Safety Agency (EASA) regulations. But instead of settling for a baseline program where data is offloaded a few times per month at most, FlyBe decided to see what benefits could be realized by pulling data more often.

The carrier outfitted some of its Bombardier Q400s with Avonica routers and QARs, and set up Wi-Fi networks at five main bases. Equipped aircraft would transmit data to the airline's servers each time they passed through one of the bases. FlyBe soon realized that having performance parameters could help their technical services team troubleshoot problems more quickly and accurately, which translated into safely keeping aircraft in service without resorting to costly manual inspections.

In one case, a FlyBe Q400 touched down hard enough to jar the passenger oxygen masks from the ceiling, and the flight crew dutifully wrote it up as a possible hard landing. Normally, the aircraft would be pulled from service and given a once-over by mechanics with input from the manufacturer. But this aircraft was equipped to offload data automatically, and FlyBe got to work. Examining a number of parameters, such as the descent rate, the airline determined the incident was not a hard landing. Bombadier concurred, and the aircraft was soon back in service, sparing FlyBe the cost of ferrying a replacement aircraft and mechanics to the scene.

The successful trials convinced FlyBe to sign on as Avonica's first airline customer for the streaming service. The vendor has upgraded its QARs so they can use cellular networks as well as Wi-Fi, meaning data can be offloaded at any station, though the carrier plans to start by outfitting its five main stations with Wi-Fi.

"The data transfer is transparent to the crew and engineers and provides us with the ability to monitor the flight data in our Flight Operations Quality Assurance program, which will lead to continuing safety benefits," says Mike Wood, FlyBe's flight operations director. "Spare [onboard wireless network] capacity will also be used to enhance the operational product, which will further improve the service which we offer to our passengers."

For MRO providers, data collection and analysis programs are similarly valuable, but often more complicated. While operators have a single entity with perhaps a few fleet types to focus on, many MROs have myriad customers and locations and, in most cases, are following customized programs for each. This leads to data programs being more internally focused.

The FAA is pushing to change that. Recognizing the value of voluntary data-sharing programs, the agency's top safety official a year ago publicly called on MROs to begin feeding data into them. Peggy Gilligan, FAA's associate administrator of Aviation Safety, noted that out of 108 Aviation Safety Action Program participants, only 10 were repair stations. The U.S.'s highest-profile program, Aviation Safety Information Analysis and Sharing (ASIAS), had no MRO providers among 80 contributors.

That changed soon after Gilligan's public appeal. AAR Corp. and Haeco Americas—formerly Timco—became the first two MRO providers to commit to contributing data to ASIAS, an eight-year-old program that aggregates data from about 185 sources.

"We've always shared between our facilities," says Art Smith, AAR's vice president and chief quality officer. "If we can share among industry, we're much safer, because we're learning at pinch points, rather than choke points."

Smith also cited the benefit among its customers. All of its U.S.-based customers have FOQA programs. "They are

transparent with their safety issues, so we want to be that way, too," Smith says.

While U.S. MRO providers may be under-represented in some data-sharing initiatives, many have well-established internal data-collection programs. AAR has been collecting different types of data for years. Some of it, like service difficulty reporting, has always been shared, while other efforts are for internal use only.

AAR has some 60 locations around the world, including six heavy MRO facilities in the U.S. Sharing information across these business lines is a key part of standardizing its services as much as possible, under what the company calls its "1MRO" approach. It also helps the company climb the learning curve more quickly. For instance, it shares issues discovered—such as a challenge with a particular procedure on a certain model aircraft—via Items for Attention dispatches that go company-wide.

The company uses internally developed software to manage its reporting, including its APRISe performance reporting information system. The software handles everything from employee self-disclosures to on-the-job injury reports. The system also folds in results from both internal and external audits, such as FAA inspections, to help paint a comprehensive picture.

AAR examines performance on a per-location basis, as well as across the organization. This allows the company to zero in on issues that may be location-specific while also keeping an eye out for broader trends.

"They are looking within organizations," says Smith of the on-location managers, "and we are looking between organizations."

The software also provides customized information in response to more requests from customers.

"We had one customer that wanted to know about the dirty dozen"—the 12 most common human factors-related maintenance mistakes—"and which ones of these [are] the biggest factors in quality escape," Smith says. "We can do that with APRISe."

Smith says nothing has changed since AAR joined ASIAS—it simply provides data to a new source. One program that has led to changes at AAR is participation in FAA's Part 145 repair station SMS pilot program. AAR's Miami heavy maintenance facility is the official participant, and works with FAA on developing documentation and procedures that could become part of an approved FAA SMS, if the agency develops an SMS mandate for repair stations.

At the moment, the program is voluntary, but since other regulators, like EASA, are pushing on with SMS requirements for MROs and most airline operators have them, many repair stations are developing them ahead of an FAA mandate.

"We've made changes to our reporting system based on what they've learned in Miami," Smith says, noting that AAR's company-wide SMS program is probably "85% developed," with the other 15% subject to details in a theoretical FAA rulemaking.

Gallery *Review some FAA safety tips for MRO facilities:* **AviationWeek.com/HangarSafety**

AMERICAN AIRLINES

CALLIE CHOAT

Choat is managing director for safety assurance and environmental programs at American Airlines. Previous positions at US Airways: director of safety assurance environmental programs and director of systems operation control. Prior to joining US Airways in 2006, Choat was senior director systems operation control for Spirit Airlines.

Safety Assurance

Callie Choat, managing director safety assurance & environmental programs at American Airlines, directs the company's safety assurance programs, which include internal evaluation, code-share surveillance, and Safety Management Systems, hazardous materials/dangerous goods and environmental and sustainability programs. She previously held positions at US Airways as director of safety assurance environmental programs and director of systems operation control. In February, Contributing Editor Heather Baldwin spoke with Choat from her Dallas office about safety risk-management at the new American.

_AW&ST_: What are American's core safety risk-management principles?

Choat: Our methodologies for managing risk are in line with SMS: Identify the hazard, assess the risk, analyze the risk and mitigate the risk. Our principles are about fostering communications between departments and eliminating the silos. We share information across all the departments and make sure each department has the time and ability, using our safety risk-management principles, to assess how a change will affect them.

How do these principles differ from the ones used prior to the integration of the airlines?

On the whole, they are no different. Everyone has always had risk-management processes in place even before SMS was standard. Working with the FAA, we spent a lot of time harmonizing safety management across all Part 121 carriers, so the programs were pretty similar. One of the big differences is that we took it a little further than the FAA SMS pilot project. We expanded the scope to include security, which wasn't required by SMS. We also expanded our scope to include hazardous materials and environmental compliance. We wanted to look at our operation as a whole and ensure that everything we do to get the planes in the sky is the safest it can possibly be.

How did you go about merging the safety risk-management efforts of American and US Airways?

We already had been sharing a lot of information as part of industry efforts to continue improving safety. Where there were differences, we looked at how they did it, how we did it, and we blended the two approaches using best practices. One of the key differences we discovered was that the US Airways risk matrix was more focused on operational considerations, not on dollars: How did a change impact customers and the operation? On the American side, there were dollars associated with levels of risk. American also looked at branding, evaluating how a change impacted its brand or name.

By sitting down and putting it together, we wound up removing the dollars portion from the risk matrix because safety isn't about dollars; it's about the impact of a change. We then expanded the risk matrix to blend other elements so that now we look at how a change affects the aircraft, the employee, the customer, the brand, security, environmental, systems and processes. We go beyond what is incorporated into SMS guidance to look at the risk to the company.

Can you speak specifically to how risk management is applied in your maintenance operation?

It is no different from the operational side. We are trying to bring together two legacy carriers with different policies and practices. Regardless of whether it is operations, customer service or maintenance, our biggest risk is how we manage change. However, one piece of Part 5 that isn't defined is how we manage risk with our vendors. The way we are approaching that is to educate them on SMS, promote safety reporting, plus we use our safety-assurance principles that include auditing and reporting to ensure they run a safe operation.

What tools are you using to manage risk throughout the company?

As part of our risk-management processes, we have several items in our toolkit. One is our risk matrix with levels of severity and assessment of risk. We also use several risk worksheets, an event risk-classification sheet for reactive events, and a risk-management worksheet for proactive, predictive changes.

One of the most important parts of risk management is system and task analysis or system description. What am I doing today? What am I doing tomorrow? Am I enhancing controls and reducing risk? On the proactive side, we look at: How is what I am doing today going to affect me tomorrow? We also have a reactive element: Why did that occur? A reactive risk assessment, based on the event as it occurred, helps the organization to understand the effectiveness of our risk controls and the remaining safety margin that exists between the event as it occurred and the credible escalated outcome.

We manage all of this through formal standardized data analysis groups and standards boards for each operational area. Currently, we are centralizing all our tools onto one SMS platform. The

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tool incorporates all risk assessments and documentation.

How would you characterize the role safety risk-management is playing at the new American versus at the individual carriers before integration?

Today, we have robust risk management at every level of the organization. We have done more than 1,700 risk assessments and trained more than 650 people to do risk management. Before, there were people trained at both airlines but it was a much smaller group. At US Airways, we had about 20 people trained to facilitate risk assessments across all organizations. American had about 40 people. So we have really been able to expand the scope.

One of the boards we put together for the merger is the Single Operating Certificate Safety Review Board, the SSRB, which includes all our principles. Every change that introduces a hazard comes through this board and they read every single safety risk assessment. It is a final QA look at a change to ensure that yes, we have identified the risk and planned for it. If a change doesn't introduce any hazards, it goes through the operational standards boards with a final QA by corporate SMS level, which includes a manager and two specialists who review it to assure the assessment is accurate.

We wound up removing the dollars portion from the risk matrix because safety isn't about dollars; it's about the impact of a change.

What have been your greatest challenges so far?

People were having trouble differentiating between a hazard and a risk. There is an industry-wide definition of hazard, but American's is broader: It's anything that could cause injury, death, damage, disruption, regulatory deviation or harm to the business or brand. A hazard could be less than an accident to an aircraft but could still affect the employee, the customer or how we do business. We had to really communicate that across the organization.

Going forward, our greatest challenge is continuing to embed the foundation and principles of SMS into every fiber of this company so that our 100,000 employees know how they contribute and what their role is in SMS. People think: 1,700 risk assessments and we're done. But we aren't. We want to be an industry leader in promoting SMS and looking for new and better ways to report information. We want to keep developing the risk index at individual departments to continue improving the overall health of the company. We feel so good about where we are with SMS, but we aren't done. It is something we will continue to do and continue to promote throughout the operation.

WESTJET

Compliance Considerations

Alternative methods of compliance for airworthiness directives

Paul Seidenman and David J. Spanovich San Francisco

When an airworthiness directive (AD) is released, it specifies the steps that must be followed in order to comply with it. In some cases, however, an airline engineering staff or MRO provider might opt to comply using an alternative method of compliance (AMOC).

"An AMOC gives the airline a choice," states Andrew Richardson, sales director of Shannon-headquartered Eirtech Aviation. "It may be economically more interesting to offer an AMOC to save downtime, costs, and complexity—providing there are sufficient numbers of aircraft flying, or the development costs versus return make sense."

Both the U.S. FAA and Europe's EASA may allow the operator to pursue an AMOC, as long as it results in the same level of safety required to satisfy the AD's requirements.

"The evolution of ADs is from 'remove this part from your aircraft' to telling the owner/operator exactly how to remove the part," says Sarah MacLeod, executive director of the Aeronautical Repair Station Association (ARSA) in Washington.

In most cases, the FAA and EASA task the design approval-holder—usually the type or supplemental type certificate (STC)-holder—to develop a fix, once an unsafe condition has been determined. The aircraft manufacturer will then tap its supplier(s) to develop that fix, which is usually issued as an OEM service bulletin (SB). However, the AD compliance method could simply reference the aircraft maintenance manual for a relatively simple process, such as disconnecting a lavatory light.

MacLeod points out that the FAA is supposed to determine the cost of following the compliance procedure the AD has established. "If the operator determines that another method is more cost-effective, and wishes to perform differently anything contained in the referenced document, it must obtain an AMOC approval from the FAA," she notes.

John Hazlet, vice president of the Hyannis, Massachusetts-based Regional Air Cargo Carriers Association (Racca), explains that an AD AMOC solution is (normally) pursued because it "is more economical, less time-consuming or better-suited to the manpower, facilities, parts and materials available to get the work done." He adds that an AMOC could also be more appropriate for the airline's fleet mix. "If the AD is targeting some article used on Boeings, Airbuses, and Douglas airplanes, and the AD was written by someone who was mostly Boeing-literate, there might be an easier way to access that article or accomplish the work on an Airbus or Douglas product that produces the same result."

Issues like this, says Hazlet, are often addressed by operators or OEMs who submit comments when the AD goes out as a notice of proposed rulemaking (NPRM). "The FAA may then insert some changes into the final rule; but sometimes not, as in the case of an emergency AD that's rushed into effect."

Eirtech Aviation developed an AMOC for an airworthiness directive for WestJet on its Boeing 737NG advanced warning cabin-pressurization system. The AMOC avoided Junction 46, which saved the time and costs of associated systems-testing.

Hazlet warns that if the carrier is considering an AMOC," it has to be prepared to support its position with very strong and detailed technical data.

"You have to be able to demonstrate, conclusively, that your proposed AMOC will maintain the integrity of what the AD is intended to address or repair," he says. "In some cases, in order to do this, the airline may have to engage the services of a designated engineering representative [DER], a designated airworthiness representative [DAR], or someone else with the appropriate engineering expertise. Typically, large airlines have the engineering capability in-house, but the smaller operators do not. And the outside experts don't work for nothing."

The AD AMOC process requires best practices, which means doing your homework. "A good place to start is Title 14 of the Code of Federal Regulations—specifically 14 CFR39.19 That's what codifies the ability to pursue an AMOC."

He also advises reading FAA Order Number 8110.103A. "This is AMOC 101, a textbook on what's required to develop and submit an AMOC application."

Hazlet recommends reading through the AD, paying particular attention to the end of the document, which specifies all the methods of compliance, the FAA's willingness to allow an AMOC, and the name of an FAA representative to contact with questions.

Because of OEM involvement in producing the documentation referenced in the AD, there's a question about to what degree the OEM will assist a company with an AMOC. That, says Hazlet, depends on the vendor. "They may provide a substantial amount of data, while others will not discuss it. And some will help, but will bill the

customer for expenses, such as engineering time. If you can't get OEM cooperation, it's best to seek the advice of a DER or DAR."

Kent Horton, director of aircraft engineering for Southwest Airlines, reports his company makes about "a couple dozen AMOC applications per year," mostly due to variations in the aircraft configuration from that anticipated in the AD documentation.

"These variations in configuration—from that anticipated in the AD mandated documentation—create a situation where there is an inability to execute the AD precisely as written. Often, alternative procedures for gaining access are needed due to the configuration being different than expected."

In fact, says Horton, most of Southwest's AD AMOC applications pertain to inspection techniques for parts that cannot easily be removed for inspection on a workbench, given structural barriers. "In those cases, we may propose an AMOC that will allow a visual inspection of the part at more frequent intervals, rather than pulling it for non-destructive inspection."

"When we begin the AMOC process, we will either petition the FAA directly, or we will do so through the airframe OEM, if the OEM has the AMOC authority from the FAA for the required solution. Most ADs are based on one or more OEM service bulletins, incorporating the compliance procedures, and the FAA will direct you to them." He adds that in some cases, the OEM will have already approached the FAA with an AMOC in the form of a service bulletin revision.

EMPIRE AIRLINES

Horton points out that a majority of Southwest's heavy inspections are outsourced to independent MROs. "If there is an AD compliance issue discovered at the MRO level, they will notify us, and at that point, we handle it. We then go through a very structured process to develop an AMOC."

The first step, he explains, is the "discovery effort" which means "understanding the true nature and details of the system configuration," while in the second step, the compliance options are assessed.

"Then you need to assure that whatever options are selected, you will come out with the equivalent level of safety—and [that] you have the ability to accomplish that," Horton notes. "All parties need to focus on the key safety aspects, as well as the details with regard to accomplishing the task. This requires excellent communication among the airline, the OEM, the FAA, and, when appropriate, the MRO."

Empire Airlines applied for an AMOC with an airworthiness directive for replacement of the ATR 72 pitot probe current sensors, because the original OEM service bulletin was no longer available at the time Empire Airlines scheduled the replacement work. The FAA approved the application, based on a revised manufacturer's service bulletin.

While costs are also considered, Horton stresses that they are "not weighted that heavily" when selecting AD compliance options. "Cost estimates are often included in the NPRM process leading up to the airworthiness directive issuance. Stakeholders will often provide comments and additional information regarding costs as part of the NPRM process."

Eirtech Aviation's Richardson ad-

AMOC APPLICATION 101

The FAA and EASA each have very specific rules regarding applications for an airworthiness directive (AD) alternative method of compliance (AMOC).

The FAA process begins with the applicant developing the AD AMOC proposal, which is submitted with an application to the FAA Aircraft Certification Office (ACO) identified in the AD.

The requirements for the applicant are spelled out in 14 CFR Part 39, Section 39.19. The FAA staff responsible for AMOCs use Order 8110.103A (Change 1), which provides policy for working with AMOC applicants. The order describes the steps in handling, coordinating, approving and denying applications.

The ACO aviation safety engineer (ASE) reviews the submitted data, and determines if it is adequate. Additional information may be requested to determine whether the request meets an acceptable level of safety. The AMOC may be approved once the responsible ACO finds the application and data acceptable in complying with the AD.

The documentation requirements vary from AD to AD, based on the applicant's proposal. Testing may be mandated, although that is on a case-by-case basis. The FAA advises applicants to coordinate early with the ACO to avoid delays resulting from additional data or document requests.

For large, complex AMOCs, the FAA may require the applicant to do a "certification" project, and absolutely will require it if the applicant wants to offer the AMOC for sale.

The manager of the ACO that issued the AD has approval authority for the AMOC, including requests for different compliance times than those specified in the AD if the AD pertains to a product manufactured in the U.S. If the AD is focused on a component manufactured outside the U.S., AMOC approvals fall under the Standards Staff branch of one of the four FAA Aircraft Certification Directorates.

vises that simplicity is among the best practices to control costs and downtime. "Look at a solution from the ground up, and try to keep it simple and avoid any complicated areas," he says, citing an AMOC recently developed for Canadian carrier WestJet's fleet of Boeing 737NGs, addressing an AD on the advanced warning cabin-pressurization system.

"Our AMOC totally avoided Junction [J] 46. This not only saves time and costs, but avoids other systems going through J46 and associated testing. J46 is a point on the 737NB where a number of systems converge. If you effectively disconnect anything going through this junction or modify [it], all associated systems would need rechecking afterward."

Richard Mills, director of quality assurance for Hayden, Idaho-based Empire Airlines, says many of the company's AMOCs have to do with paperwork driven by revisions to documents, such as the OEM service bulletins referenced in the ADs. "For example, let's say an AD's instructions specify accomplishing a modification in accordance with manufacturer's service bulletin Revision 1," he says. "The AD's instructions might allow the operator 2,000 flight hours or one year from its effective date to accomplish the AD, so the operator schedules accomplishment six months later. In the meantime, the manufacturer issues revision 2 with substantive changes to the accomplishment instructions. Consequently, the operator who is reviewing service bulletin revisions will choose to apply for an AMOC that will allow him to use the later revision."

As Mills explains, there have been times when the FAA has issued an NPRM for an AD with a long comment period, and by the time the final rule is published, the referenced service bulletin has been revised. However, the FAA has not modified the text in the published document to require accomplishment using that revised service bulletin. "This situation would require applying for an AMOC."

Mills adds that if a service bulletin has been superseded—and the one referenced in the AD is no longer available—the operator has no option but to apply for an AMOC. He cites a case involving a member of the ATR family, of which Empire operates 31.

"AD2008-13-19 paragraph (f)(2) required replacement of the pitot probe current sensors on the ATR 72-212 in accordance with Avions de Transport Regional (ATR) Service Bulletin ATR 72-30-1042, Revision 1, dated June 1, 2005. The AD itself, incorporating Revision 1, did not become a final rule until 2008. By the time accomplishment was possible, ATR 72-30-1042, Revision 2, dated Jan. 15, 2009, had been issued. We requested an AMOC to use Revision 2. In this case, because Revision 1 was no longer available from the manufacturer," says Mills.

The FAA was satisfied that use of the later revision provided an acceptable level of safety since it accomplished the intent of the AD and adequately addressed the unsafe condition identified by the AD. "The benefit to us in this case was obvious: The revision was our only available means to comply with the AD," says Mills.

Sizing Up Service

AAR Chairman and CEO David Storch reveals the thought process behind changes underway at the successful aviation services business. Chief Editor-MRO Lee Ann Shay interviewed him at AAR's headquarters before the company announced plans to sell its cargo manufacturing businesses to TransDigm.

DAVID STORCH

Joined AAR Corp. in 1979 with responsibility to develop the engine business and became president of AAR Trading Group in 1987. In 1989, he was promoted to president and COO, followed by the additional role of CEO in 1996. Storch is only the second CEO since AAR was founded in 1955. He added the post of chairman in 2005.

_AW&ST_: What's the split of your portfolio and how do you expect it to change over the next 3-5 years?

Storch: AAR started in the parts business and over the years moved into maintenance and manufacturing. Over time, we tried to build a company that could weather different financial storms. At one point, 25% our revenues were from airlines—such as TWA and Eastern—in bankruptcy. As we successfully progressed through the 1990s, along came 9/11, and we had pivoted our business to many U.S. airlines that filed for bankruptcy. As we came through the 9/11 aftermath, we felt that it was in our best interest to have a more diversified portfolio. We shifted to a blend of manufacturing and services, domestic and international, military and commercial activities. Before 9/11, 87% of our business was with airlines, and now it's 65% commercial and 35% military.

But the world landscape is different today: Unlike prior decades and cycles, U.S. commercial airlines are on a more solid footing. You've seen us grow MRO activities, but so far they're all North-American centric—so we have our sights on international growth. We've expanded by taking advantage of certain dislocations; our first major move into MRO was United's Indianapolis facility; the next was taking on Northwest's former facility in Duluth, Minnesota, followed by the former EADS facility in Louisiana. The latest is in the state of Illinois, which has assisted us to expand our operation into Rockford. As time goes on, I think the U.S. carrier base will grow and we'll be in a good position to capture that growth.

What's your view of the widebody market?

The labor rate gap around the world is starting to close, especially in higher-cost places like Shanghai and Hong Kong. I'm betting that I can create a value proposition for airlines that will encourage them to do work in the states.

Are you happy with the ramp-up at the Lake Charles facility?

It's been slower than expected. When we took on that facility, A330 work was underway. We retained that type of MRO and recently captured more. The new widebody hangar is booked through the end of the fiscal year (May 31), but we still have capacity in our other hangars.

AAR recently was selected by AMMROC to support its military facility in Al Ain—and AAR is providing airlift in Africa.

When you think of AAR defense, there are three buckets: things we manufacture (shelters, containers, pallets), and that business has been soft. (AAR is selling its cargo manufacturing business to TransDigm for $725 million.)

Airlift has been very strong—but is going through a period of transition. It was heavily based on Afghanistan activity before, which has diminished, but we're still there. Now we're seeing activities in Africa that we didn't see before—so we're transitioning from one area of high demand to another.

The piece of business I particularly feel good about is supply chain. Military fleets are aging and budgets are shrinking, but aircraft have to be serviceable. While the U.S. military budget is declining, regions such as the Middle East have growing budgets and new fleets—including Saudi Arabia and the UAE. We haven't had the success yet in Saudi Arabia that we've had in the UAE, but I hope that success isn't too far off.

We view the Africa market opportunistically. On the commercial side, we won a 737NG component support contract with Kenya Airways and we're looking at a few possibilities there—but we're just getting started.

AAR started the consumables program with a U.S. major—a $48 million annual contract to procure and manage parts. Do you expect more airlines to outsource expendables?

This program is an extension of ways we can help airlines be more efficient—by managing their staffing and inventory levels with somebody who specializes in this. It's a low-margin activity but it's a nice addition to our suite of solutions. I don't think there's a blanket solution for airlines. What we're trying to do is to create a value proposition that is compelling, and the broader that solution set is, the better our chance to capture more business—whether they need to source, procure, warehouse, manage obsolescence factors and or sell off what they don't need.

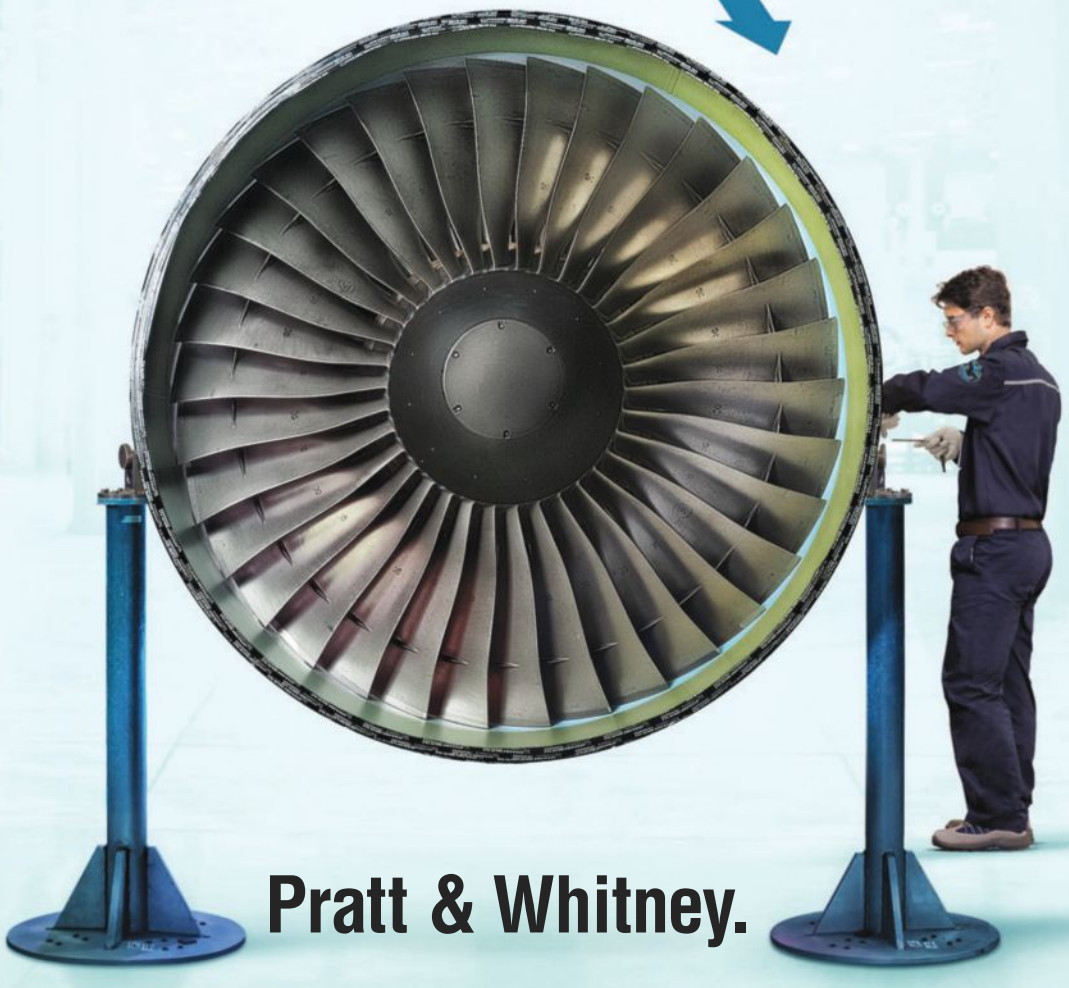
How long will it be before AAR gets into full lifecycle support?

We're doing a fair amount of that already with Mesa's Embraer 175s. United owns the aircraft but Mesa operates the fleet. We have a maintenance agreement on the aircraft and a power by the hour agreement for the spare parts—so it's pretty close. We don't do the APUs, engines or landing gear.

The MRO market is very fragmented—is that part of the reason AAR created the 1MRO concept?

The 1MRO goal is that an airline gets the same experience at any of our facilities. Each unit will perform at high level and consistently. We have two company pillars: innovation and execution. You need both, and Apple does really well with this. That's how I'd like AAR to shake out in aerospace—I want to be innovating and figuring out ways to help our customers be more competitive—giving them a great product and a great price, with a focus on safety of flight. If I achieve that, we have success.

THE SHORTEST DISTANCE BETWEEN YOU AND LOWER COSTS?



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Better Connections

New ways to transmit aircraft data are cheaper than ACARS

JOEPREISAVIATION.NET

Henry Canaday Washington

Hawaiian Airlines uses tablets running WxOps software to collect data for real-time operations and maintenance control.

Everybody has been talking about it for years, and now it is finally starting to happen. It, here, means connecting aircraft in flight with the ground in a truly robust fashion, enabling the massive amounts of data modern aircraft can generate to reach the ground in time to improve operations and assist timely maintenance decisions; for instance, by prepositioning skilled mechanics, materials and tools at the gate before landing.

Technologies certainly exist to accomplish this, but the key has always been doing it economically for costs justified by the payoffs. Satellites and Internet Protocol (IP) communication now offer more affordable communication links. And if exchange of operational data can be combined with data for passengers in the cabin, further efficiencies may result. But this is a young field, and there are several approaches to achieving better connections.

For example, WxOps will provide Hawaiian Airlines with software to massively increase the operational data it transmits and receives from its en route aircraft. Data sent every few minutes will include position reporting, telemetry, aircraft-reported meteorological data, fuel status, aircraft systems data and much more.

WxOps' software operates on tablets mounted in the cockpit, connected to an aircraft server and IP satellite transceiver. The always-on transceiver communicates with Inmarsat satellites worldwide.

WxOps COO Albert Peterlin stresses that airline operations will be enhanced by more timely and accurate communication with the aircraft. "This new process gives the airline the ability to modify flight paths and reduce costs after departure due to changing traffic control, weather hazards, fuel conservation and on-time performance."

A massive amount of data will be transmitted, including maintenance-related data such as minimum equipment lists, systems diagnostics and alerts. Hawaiian will use the data for real-time operational and maintenance control and many other purposes.

After launching the software with Hawaiian, WxOPs plans to offer it to other carriers. Hawaiian flies Boeing 717s, 767s and Airbus A330s, but WxOPs can report whatever data is generated by more modern models.

Peterlin says always-on IP and excellent data compression will deliver more timely data than traditional systems like ACARS, and the WxOPs approach will integrate the data more thoroughly with the airline departments that use it, including operations and maintenance.

Installation of the system takes one to two weeks, and requires the airline to have aircraft and ground control servers, satellite and cellular connectors and ARINC 429/717 connectors.

Pressure for solutions like WxOps is coming from new aircraft models and new data demands. Today, operational and maintenance data can be been transmitted over GLOBALink through the many media that support ACARS. But the amount of data transmitted over ACARS is in tens of thousands of kilobits, notes Peter Grogan, senior director of GLOBALink Data Services for Rockwell Collins. Maintenance data—in kilobytes to megabytes—is generally transmitted at the gate.

Moreover, next-generation aircraft can be configured with data requirements that strain ACARS capabilities. Grogan says new solutions will be necessary, and harmonizing them will be an industry challenge. Fortunately, Boeing 787s, Airbus A380s and Airbus A350s can easily use broadband IP to transmit some data.

SITA is taking a more integrated approach to the challenge. It has formed a SITA OnAir business unit to combine SITA's expertise in crew, operational, air traffic and maintenance connections with OnAir tools for connecting passengers in the cabin to entertainment and communications.

Chief Strategy and Marketing Officer Francois Rodriguez says connectivity is due to boom for two reasons. First, new aircraft like the 787 and A350 are generating huge amounts of operating data. "It's critical to get the data off en route," Rodriguez says. He believes ACARS is too expensive to transmit so much data en route, and downloading data at gates is too late for timely decisions.

Second, airlines are seeking Wi-Fi and Global System for Mobile Communications (GSM) connections for passenger entertainment and phone usage. Satellite communication links to serve these needs open up "more pipes" for cockpit data, Rodriguez notes. A combined solution to both cockpit and cabin needs will be more efficient and pose fewer implementation challenges for airlines. "We are putting together an ecosystem for the airborne aircraft and ground operations."

SITA will use IP and other communication links to update weather, provide flight tracking, support EFBs, report defects and other critical operational data, while OnAir links passengers to the ground. Solutions will be scalable and fit any aircraft. Separate "vertical solutions make airline life very difficult," Rodriguez argues. "You end up with different hardware, systems, spares and training." He says the combined system can be installed in 24 hours.

PW4000: A Valuable Engine Market

MRO market competitive for engine family that will generate 2,730 shop visits in 2015-19

Henry Canaday Washington

PRATT & WHITNEY

The Pratt & Whitney PW4000 family will require 2,730 shop visits in the next five years. A PW4000-100 Advantage 70 is shown here.

As successor to Pratt & Whitney's JT9D, Pratt's PW4000 family powers the Airbus A300, 310 and A330, as well as Boeing 747-400, 767, 777, KC-46 and MD-11. Nearly 2,300 PW4000s are still in service this year; that is expected to decline slightly to 2,150 in 2019. Two-thirds are PW4000-94s now, but this share will decline to less than 60% in four years, as the -100 becomes more important, while the -112 stays fairly stable at about 330 engines.

This is a mature family of engines; they first operated in 1987, and the -112, designed for the 777, is its youngest model. As a whole, the PW4000 family will require a total of 2,730 shop visits in the five years from 2015-19, according to Aviation Week's MRO Prospector. Activity will peak in 2016, with 573 visits, and in 2018, with 595. Here too, the -94 dominates, with about 60% of visits this year, declining to 56% in 2019. The -100 and -112 split the remainder, with the -100 requiring more than 600 visits over the period and the -112 slightly less than 600 visits.

Expenditures on PW4000 overhauls will total slightly more than $9 billion from 2015-19, MRO Prospector estimates. The peak years again are 2016 and 2018, with nearly $2 billion of shop work done in each of these years.

Pratt & Whitney Eagle Services Asia is the OEM's global center of excellence for PW4000 engine overhauls. Based in Singapore, Eagle Services can overhaul up to 300 jet engines annually, or more than half the average shop visits expected in the medium term. In addition, "there are some airline and third-party engine MRO providers who possess capability for the PW4000 with varying limitations," acknowledges William Kircher, vice president, Pratt & Whitney Singapore Overhaul & Repair and president, UTC Aerospace Singapore.

The market for PW4000 overhauls is not crowded, like that for narrowbody engines such as the CFM56. But the PW4000 family powers widebodies flown by some of the world's largest airlines, so in-house airline capacity is substantial and often available to other carriers. For example, Air France KLM E&M supports the PW4000, and Lufthansa Technik and Delta TechOps overhaul the -94.

Though not huge, this is a valuable business. MRO Prospector estimates that total maintenance spending per engine-year will average nearly $600,000 for the -94, $800,000 per engine-year for the -100 and more than $1.7 million per engine-year for the -112. Actual costs will vary substantially, especially for overhauls. Kircher notes that overhauling a PW4000 can take a couple of weeks to several months, depending on the work-scope, model, age and condition of the engine.

Customizing work-scopes to fit each customer's needs is probably most important for mature engines like the PW4000. Some aircraft and engines may not need all the life that could be added by the fullest overhauls. But these engines still power some very valuable widebodies, and declining oil prices may extend the lives of some older engines.

Access to used parts is especially important in economizing on repair costs for mature engines. As the OEM, Pratt offers a wide choice of new and used parts. But global MROs are also building up access to spare parts, using tear-down facilities and other means.

Pratt & Whitney PW4000 Engine Family

ENGINE	THRUST	AIRCRAFT	ENTERED SERVICE
PW4000-94	52,000-62,000 lb.	Boeing 747, 767 and MD-11, Airbus A300/A310	1987
PW4000-100	64,500-70,000 lb.	Airbus A330	1994
PW4000-112	74,000-90,000 lb.	Boeing 777	1995

Source: Pratt & Whitney

Washington

Staffing Up

The FAA's fiscal year 2016 budget request reflects the agency's challenging reality of trying to do more with less. Its overall request of $15.83 billion is a slight decrease from what it ended up with for 2015, but boosts funding for some high-profile programs, including NextGen and maintenance of existing air traffic control facilities.

Despite efforts to streamline certification and safety surveillance efforts with programs such as designees and risk-based safety oversight, the Office of Aviation Safety (AVS) is still in line for more resources. The agency's official request would boost AVS programmatic funding—money not tied to routine personnel expenses such as pay raises and benefits—by $21.3 million over this year's pot. The AVS budget request, which totals $1.26 billion or 3.3% above 2015, also asks for 85 new full-time-equivalent (FTE) staffers, mostly safety inspectors and engineers for both surveillance and certification.

SEAN BRODERICK/AW&ST

The FAA's 2016 budget request, while an overall reduction from 2015's level, includes funds for more safety inspectors and aircraft certification engineers.

"AVS forecasts the need for additional safety personnel to meet projected demands for industry oversight and certification services, while continuing to expand delegation responsibilities to designees," the agency explained in its budget request. "FAA/AVS forecasts out-year growth in the demand for the number of type certification design approvals required by applicants, production certificates provided to manufacturers and supplier control audits conducted at manufacturers."

Some of these demands are evolutionary, such as FAA adopting the widespread acceptance of data-driven risk management. The agency is lobbying hard to expand participants in voluntary data-aggregation programs such as the Aviation Safety Information Analysis and Sharing Program. But making prudent use of that data requires more FAA resources—a fact not lost on industry, as it ponders whether to invest its own resources.

Others, such as staffing up to add a new class of aircraft—unmanned aerial systems (UAS)—to the national airspace system, are more revolutionary.

"The AVS request also includes funding to focus on oversight and training for designee supervision and the integration of manned and unmanned aircraft into the National Airspace System," the FAA explains. "This staffing request is aligned with the forecasted staffing requirements included in the AVS Workforce Plan."

The budget request would push AVS's total FTE staff to 7,246, adding

54 to surveillance and oversight, 29 to certification and UAS integration and two to its SMS program.

FAA's overall request includes funds for 44,213 total "directly funded" FTEs—120 more than its enacted 2015 budget.

Sean Broderick/Washington

Europe

True Grit

Volcanic ash-related damage most likely did not contribute to the failure of a Thomas Cook Airbus A330-200's No. 2 engine at Manchester Airport in June 2013, a U.K. Air Accidents Investigation Branch (AAIB) incident report addendum says.

The incident took place as the A330 was rolling down Manchester's Runway 23R during a scheduled departure for Punta Cana in the Dominican Republic. At 105 kt, the aircraft suddenly yawed to the right. The captain took control and aborted the takeoff.

Video of the incident shot by an onlooker showed a flash of flame and cloud of smoke exiting the engine's exhaust, followed by the aircraft coming to a stop 22 sec. later. After pausing on the airfield to cool its brakes, the aircraft was cleared by emergency services to return to the terminal, where all 328 passengers and 11 crew disembarked.

The investigation revealed that a high-pressure (HP) turbine blade detached just above its root fixing. Metallic debris from the detached blade started a chain reaction that damaged the intermediate- and low-pressure turbines and nozzles, which created more debris and ultimately the seizure of both the intermediate- and low-pressure spools.

"Laboratory analysis of the fractured blade root found multiple crack initiation locations caused by Type 2 Sulphidation corrosion," AAIB noted in its original incident report. The particular type of corrosion is caused by mixing high-temperature components with sulphur, which could come from fuel or airborne contaminants, including volcanic ash. In this case, the corrosion led to a crack subjected to high-cycle fatigue propagation.

Further investigation of the blade noted "unidentified deposits," which

NIGEL PREVITT/AW&ST

Corrosion that led this A330's No. 2 engine to fail probably did not involve volcanic ash, though investigators cannot rule it out.

Rolls-Royce examined in detail after AAIB's initial report was published.

"There was concern that these deposits may have been volcanic in origin, in particular from the 2010 eruption of Eyjafjallajokull in Iceland, so additional forensic analysis was carried out," AAIB explains.

The analysis "did not identify compounds typically associated with volcanic activity," AAIB notes in its addendum. "However, although an encounter with volcanic gaseous sulphur cannot be discounted it is concluded that the deposits probably are an accumulation of atmospheric dirt and pollutants." The engine that failed had 5,200 cycles since its last overhaul.

The importance of avoiding both concentrated and diffuse volcanic ash clouds has long been known, but has been spotlighted in recent years thanks in part to the 2010 Eyjafjallajokull eruption that shut down some European airspace. While concentrated clouds are more dangerous, diffuse clouds are problematic because they are hard to detect and often cause engine performance degradation and irreversible aircraft damage.

The International Civil Aviation Organization in 2012 published a guide on flight safety and volcanic ash that includes post-incident response guidance. The AAIB report does not link the A330's flight history with a known volcanic ash cloud encounter.

Sean Broderick/Washington

Safety Protocol

Regina Kenney Chicago

1. Firefighting foam for MROs

Company: Red Dog Services
Product: Compressed-air foam system
Specifications: It is a scary to think of fires breaking out in the workplace, especially in the aviation industry because of the volume of flammable chemicals that MRO professionals use. Choosing the correct products to extinguish fires quickly and efficiently can be a life-or-death decision. The Suppressor 20 from Red Dog Services is a compressed-air foam system with a 20-gal. solution tank for extinguishing fires. About the size of a pickup-truck tool box, the suppressor delivers a stream of firefighting foam at a range of approximately 50 ft. The system is powered by an 80-cu.-ft., 2,200-psi. nitrogen cylinder and does not require an outside energy source. It can generate up to 400 gal. of finished foam, depending on the solution. Freeze-protected foam can be used for cold climates.
www.reddogservices.com

LINK #1040

2. Three stages to better air quality

Company: A.J. Dralle
Product: Aerospace filtration system
Specifications: Aircraft repair can result in large amounts of dust and debris that is a potential hazard for mechanics. Having proper air filters for a hangar is essential for keeping workers safe. The high-efficiency particulate air (HEPA)-XFP is a three-stage aerospace filtration system from A.J. Dralle that is designed for HEPA-required paint booth exhaust systems using chromate formulations. The first stage of the HEPA-XFP is a multi-layered polestar media where the air enters. It is made of a mixture of densified fiber and is inkjet-printed for identification and proper installation. The second stage consists of two layers of polyester media that are sealed together; and the third stage features a six-pocket bag filter constructed using three plies of electrostatic media. There is no HEPA framework needed as the HEPA-XFP fits into standard three-stage filtration frames.
www.ajdrallefilters.com

LINK #1083

3. MRO Hand protection

Company: Aircraft Shop Supply
Product: Shoulder leather palm gloves
Specifications: Aircraft Shop Supply's leather palm gloves are made of fabric, cowhide leather palms and rubberized safety cuffs. They are available in assorted fabric colors. These gloves can be used for myriad tasks including abrasive applications and assembly.
www.145.aero

LINK #1084

4. Protect hands from splashes and spills

Company: Apollo Performance Gloves
Product: Chemical-resistant gloves
Specifications: MRO facilities use many chemicals that can harm workers. The Quick Response (QR) chemical gloves from Apollo are neoprene with flock lining and are 30 mils thick. The gloves have been tested with more than 100 common industrial chemicals. They are resistant to cleaning chemicals, mild acids, caustics and many organic solvents including aliphatic hydrocarbons and fuel. The gloves include a QR code for easy access to chemical-resistance information and a low-odor formula so they will not retain a strong chemical smell after use.
www.apgloves.com

LINK #1085

5. Secure your hazmat shipping procedures

Company: BTA International
Product: Containers for hazardous materials
Specifications: BTA provides tested containers for shipping hazardous materials on airliners and is focused on the aviation industry. These containers come with free test reports, where applicable, with every order. Containers range from those for oxygen cylinders to complex slides/rafts. BTA also offers customized solutions, with capabilities in the design, quoting and delivery of proper packaging, based on the component.
www.ebta.net

LINK #1086

6. Spring-cleaning the MRO facility

Company: Chappell Supply and Equipment
Product: Wet/dry vacuum
Specifications: Keeping the workplace clean decreases the numbers of trips and falls. The wet/dry vacuum cleaners from Chappell Supply and Equipment contain two-stage blowers and a self-cooling motor. The vacuum's exhaust air-ducting reduces the possibility of motor contamination by dirt or moisture. By eliminating airborne particles through exhaust, the vacuum helps keep workplaces safe. Most of the vacuums have a decibel rating of 63.4 dba to provide a quiet operation.
www.chappellsupply.com

LINK #074

Enter Link # at www.AviationWeek.com/MROLinks for more information.

7. Safer wires to eliminate injury

Company: Daniel's Manufacturing Corp.
Product: Safe-T-Cable
Specifications: Daniel's Manufacturing designed the Safe-T-Cable to replace lockwire systems and improve the security of fasteners. The Safe-T-Cable is constructed of high tensile-strength stranded cable and cable ends that are electrically fused to allow easy threading. The cable is pre-cut to various lengths and is lighter in weight than safety wire. This new cable eliminates injuries from sharp wire ends and reduces the risk of carpal-tunnel injuries.
www.dmctools.com
LINK #472

8. Storing and shipping oxygen cylinders

Company: HRD Aero Systems
Product: Aer02case
Specifications: The Aer02case is an Air Transport Association (ATA) container for oxygen cylinders and oxygen generators from HRD Aero Systems. The containers are ATA/U.S. Transportation Department-approved and comply with the department's regulation for transporting oxygen cylinders on aircraft, with the required thermal and fire protective packaging. HRD ships to distribution centers in the U.S., Singapore and Europe.
www.hrd-aerosystems.com
LINK #852

9. Hybrid hangar of fabric and steel

Company: Legacy Building Solutions
Product: Fabric aircraft hangars
Specifications: Legacy's fabric aircraft hangar features a translucent fabric roof with a steel frame. The structure is created using the same rigid frame technology as in steel hangars but with natural light due to the fire-resistant fabric. These hangars accommodate heating, ventilation and air conditioning systems. The buildings can be constructed in about half the time as traditional steel structures and be moved, expanded or reduced as needed. They meet the safety standards for construction and fire protection set by the National Fire Protection Association.
www.legacybuildingsolutions.com
LINK #968

10. Decrease facility and aircraft damage

Company: Mantec Services
Product: Safety bumpers
Specifications: Mantec specializes in designing and manufacturing safety bumpers for the aerospace industry from a self-skinning polyurethane foam. This foam locks out moisture and features ultraviolet and abrasion resistance, high tear strength, and resistance to solvents and chemicals such as Skydrol. The bumpers are designed to protect rigid parts, such as folly corners and lifts, from damaging aircraft and buildings. The material is designed to be nonconductive, environmentally safe—without chlorofluorocarbons or volatile organic compounds—and to meet fire-retardant specifications.
www.mantecservicesinc.com
LINK #586

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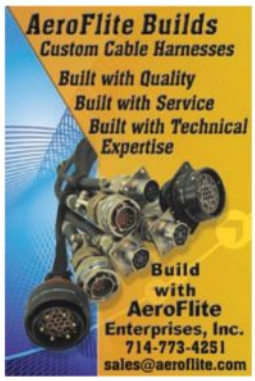

AeroFlite Enterprises, Inc. is an authorized stocking distributor specializing in the assembly of electrical connectors, wire harnesses and custom cable assemblies qualified to the highest of all industry standards while at the same time providing unparalleled customer support and service.

Parts Distributor

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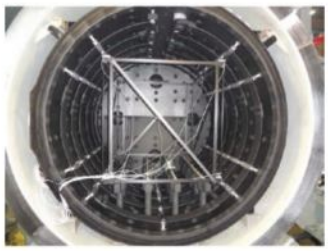

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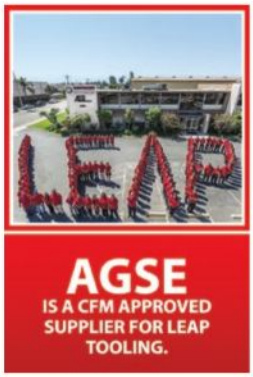

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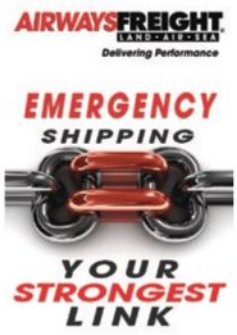

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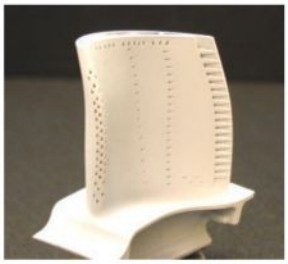

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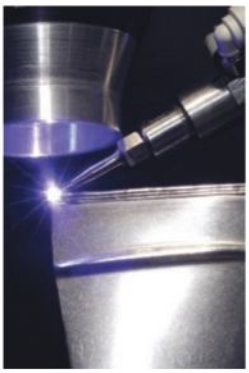

Components

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Painting/Coatings

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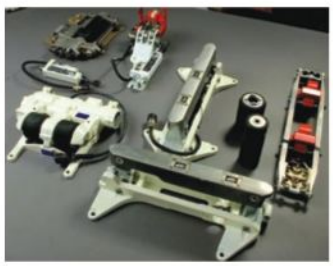

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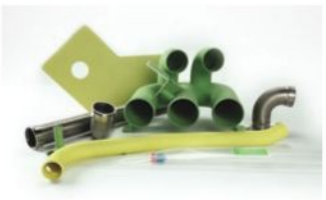

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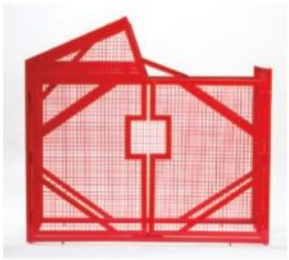

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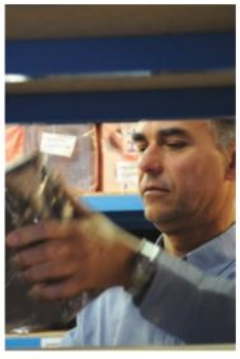

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What's Next?

There has been significant progress in airline consolidation in some markets, but the momentum is slowing

Cathy Buyck Brussels and Jens Flottau Frankfurt

When American Airlines and US Airways finally completed their merger in late 2013, it marked the end of an era. This remarkably formative period saw the creation of formidable airline blocks worldwide. But with many of the major deals accomplished, the question now is what lies ahead in terms of airlines maintaining their fiscal health.

A brief recap of the recent U.S. mergers shows: Delta Air Lines/Northwest Airlines, United Airlines/Continental Airlines, American/US Airways, and Southwest's takeover of AirTran. In Europe, Air France merged with KLM; Lufthansa bought Swiss International Airlines, Austrian Airlines and 49% of Brussels Airlines; and the International Airlines Group (IAG) came into being. IAG now comprises British Airways, Iberia and Vueling Airlines.

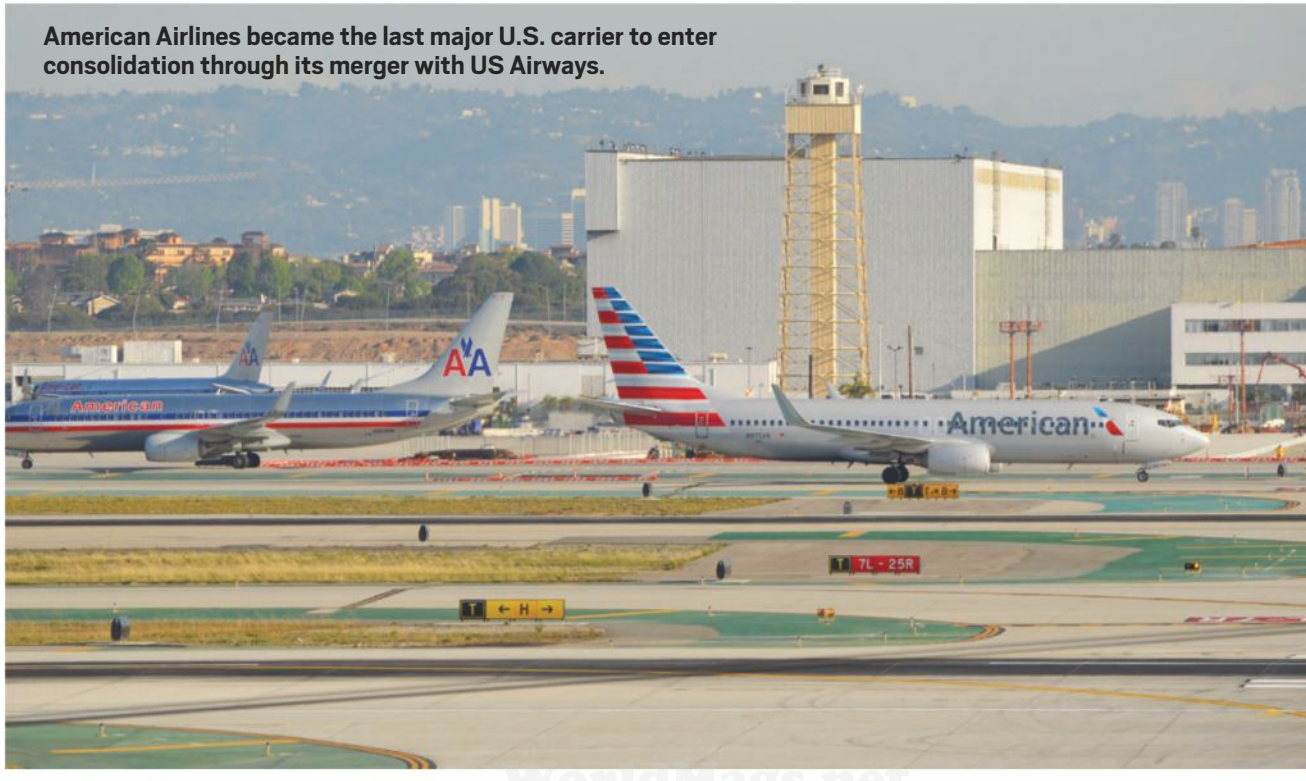
In China, the three major carriers—Air China, China Southern Airlines and China Eastern Airlines—were directed by the central government to take many of the smaller provincial airlines under their umbrellas.

In Latin America, LAN Airlines and TAM Brazil merged to form the Latam Airlines Group and Avianca has subsumed Grupo Taca and AeroGal.

Even though they are not the result of mergers, over the past 10 years three large carriers have emerged from the Gulf states, marginalizing many other airlines in that part of the world. And as part of changes wrought by the low-cost carrier (LCC) model in the Asia-Pacific market, new leaders have emerged in that region, including Malaysia's AirAsia with its various regional affiliates and its long-haul subsidiary, AirAsia X.

That is a lot of action. However various factors indicate not to expect much more of the same. Although, due to changing global industry dynamics, different patterns may emerge, as shown by Qatar Airways' recent investment in IAG.

Many regions appear merger-resistant because the airlines are still controlled by governments that have no intention of relinquishing that role. That is true for Africa, the Middle East and large parts of Asia. The question will be whether economic realities will eventually force at least some form of closer cooperation. So far most efforts, such as the proposed joint venture of Egyptair, Ethiopian Airlines and South African Airways for West Africa, have failed. And in 2012, then-Royal Jordanian Airlines Chief Executive Hussein Dabbas suggested that a strategic alliance with the possibility of cross ownership (with guarantees that the airline's brand would be maintained) might be necessary to counter competition from megacarriers in the region and in Europe. But this was swiftly quashed; Dabbas resigned weeks after his call for consolidation in the Middle East.



American Airlines became the last major U.S. carrier to enter consolidation through its merger with US Airways.

NIGEL HOWARTH/AW&ST

European LCCs such as Ryanair and EasyJet have driven other competitors into joining forces to stay afloat.

NIGEL HOWARTH/AW&ST

The most active region in terms of mergers and takeovers remains Europe, but even there the pace has slowed markedly. A large part of the industry is actually up for sale, so it would seem logical that more mergers will be underway. Mid-size carriers such as Air Baltic, LOT Polish Airlines and TAP Portugal have been looking for new investors for years, but have had to hang in there on their own or with European Commission (EC)-approved government support. The lack of strategic investors—financially sound airlines—has dropped in Europe for a variety of reasons: Air France-KLM and Lufthansa Group are preoccupied with their own restructuring. They simply do not have the management or financial resources available for additional mergers. Alexandre de Juniac, CEO of Air France-KLM, has publicly stated as much when queried about why he did not acquire Alitalia.

Aspirations of creating a group with three European hubs, Charles de Gaulle in Paris, Schiphol in Amsterdam and Fiumicino in Rome, were dashed last year when Etihad Airways acquired a 49% shareholding in Alitalia.

IAG is the one exception. Although late to the game, it is currently the main driver of consolidation. British Airways' (BA) tactical retreat to its London Heathrow hub has made that airline less vulnerable for LCC competition. The restructuring of Iberia has come quicker than expected by many, including IAG CEO Willie Walsh, and the group has already acquired LCC Vueling and is now interested in Aer Lingus.

The initiative follows a simple rationale: Focus on your strengths. IAG's strengths are clearly the Heathrow hub and, more generally, its competitive position across the North Atlantic, where it also benefits from the antitrust-immunized joint venture with Oneworld partner American Airlines. Aer Lingus has slowly built up a profitable transatlantic business from Dublin, but is now connecting other markets where it makes sense economically and geographically. Including Aer Lingus in the transatlantic joint venture would likely benefit both sides. IAG can afford to pursue such a deal because its financial situation is much better than that of most European legacy peers. In fiscal 2014, the group recorded a €1.4 billion ($1.51 billion) operating profit, up 80.5% on the prior year, and is targeting double-digit operating margins ahead.

By way of comparison: Air France-KLM recorded an €129 million operating loss last year, partially related to a two-week strike by Air France pilots protesting the establishment of a pan-European LCC with bases outside its two home markets.

De Juniac probably also realized he would never be able to restructure Alitalia due to touchy nationality issues. A Franco-Dutch group imposing stringent cost cuts would not sit well with Alitalia's employees, nor Italians in general. Spanish politicians called for a reversal of the BA-Iberia merger when IAG started downsizing the Spanish flag carrier to reduce costs. Tension is also rising within Air France-KLM, which set the European multibrand, multihub consolidation model 10 years ago, as the need to restructure intensifies. De Juniac was called to The Hague to explain new cost-cutting measures, and Dutch politicians have voiced concerns that reforms commanded by Paris could damage Schiphol's standing and the country's economic interests. The Dutch and French transport ministers, as well as de Juniac and KLM CEO Pieter Elbers are slated to meet in Paris this month to discuss KLM's sovereignty and Air France-KLM's intent to further integrate the Dutch airline.

Meanwhile plans for "cash pooling" and the transfer of KLM's cash management to the parent company's headquarters in Paris were abandoned in January following massive resistance from KLM management and politicians.

Rigas Doganis, a former professor at Cranfield University's Center for Air Transport Management and author of *Flying Off Course: Airline Economics and Marketing*, cautions against national pride. "The consolidation of legacy airlines we had in Europe is superficial because of nationality rules in bilateral air services agreements and the desire of countries to safeguard their flag carrier," he says. Air France and KLM each maintained separate cost structures, brands, headquarters, profit-and-loss accounts, CEOs and aircraft configurations. "Air France had to give a lot of assurances and concessions to the Dutch government." Similar concessions are in play for the IAG/Aer Lingus deal, Doganis says.

He sees no rational reason why IAG could not in the longer term drop the Iberia name or Lufthansa abolish the Brussels Airlines brand and operate out of the Belgian capital as Lufthansa. Several iconic brands have disappeared in the consolidation process of the U.S. airline industry and it should be possible in Europe, he asserts. He notes that genuine consolidation has happened in Europe's low-cost segment.

Many LCCs such as MyTravelLite, SkyEurope, Sterling Airlines and Bmibaby have gone bankrupt or ceased operations. Ryanair bought KLM's U.K. budget airline Buzz, EasyJet purchased Go Fly from BA and Vueling merged with Clickair. As with U.S. airline consolidation, Europe's LCCs fully integrated the operations, management and brand of the airlines they acquired. The four leading LCCs control most of the low-cost business in Europe.

More consolidation will happen in Europe, contends Simon McNamara, director general of the European Regions Airline Association. He does not see it taking place among regional airlines, which operate in specific niche markets or provide capacity on an ACMI (wet-lease) basis to larger airlines, but he does see low-cost and

network carriers consolidating further.

This might be driven by market exits as well as acquisitions and mergers, predicts Doganis, who describes many of the continent's small and midsize flag carriers as an "endangered species." They are "too small to compete effectively against big legacies in long-haul and too high cost to compete effectively against the LCCs on short-haul."

The EC, however, is cautious about unbridled consolidation and the possible negative impact on connectivity, jobs and economic growth, which are pillars of the EC's new Juncker Commission that took office on Nov. 1, 2014, and is due to serve until 2019. Keeping a balance between consolidation and the need for direct air connections between smaller capital cities and other major European economic hubs is a challenge, a senior official of the EC's Transport directorate general says. He points out that consolidation is part of the equation for keeping airlines competitive. The European Union has strict rules on state and rescue or restructuring aid and the market will consolidate based on these rules. On the other hand, aviation is a driver of economic growth. Budapest, Hungary, and Nicosia [the capital and largest city on the island of Cyprus] lost "business-type" air services when they lost their flag carriers. Then we must ask if these nations are still capable of providing a good business environment, he notes. The EC aims to address this issue as part of its new aviation strategy, due later this year.

The majority of equity deals in Europe in recent years have involved Middle Eastern and Asian investors, not European. Korean Air bought into CSA Czech Airlines, HNA Group in Aigle Azur, and Henan Civil Aviation and Investment Co. (an investment arm of China's Henan province) took ownership of a 35% stake in Luxembourg-based Cargolux Airlines. Etihad acquired large stakes in two major European airlines—29.2% in Air Berlin and 49% in Alitalia—and 49% in Air Serbia. In a way, the Abu Dhabi-based airline is filling a void left by the big European players. Six years ago, Lufthansa, at the eleventh hour, halted its proposal to buy Alitalia, deciding it was too risky. And Air France-KLM sought to buy Air Berlin four years ago, but the German airline's management did not want to give up control.

As long as ownership and control limits remain unchanged, Etihad's role will always be that of a strong minority shareholder, even though many competitors are convinced the carrier has effective control of Air Berlin and Alitalia. A complete takeover is impossible, nevertheless, and it seems more targets may be hard to find.

One of the biggest open questions in European air transport remains the future of Scandinavian Airlines (SAS), the last large legacy that is neither a member of the Big Three alliances nor associated with a foreign investor. Rumors abound that SAS is next on Etihad's European list, but it may well be that the United Arab Emirates-owned carrier is turning to markets where it lacks the kind of in-depth relationships it has established in Europe, namely North America and Asia-Pacific beyond India (where Etihad partners with Jet Airways).

Stage 2 of the Gulf carrier involvement in European airlines has not been achieved by Etihad, but by its archrival, Qatar Airways. The latter in January became the first to buy a stake in one of the Big Three European groups—Qatar has controlled 9.99% of IAG since late January. While the same ownership and control limitations apply, the significance of the deal lies in the alignment of interests. IAG CEO Walsh has been the most active in seeking cooperation with a Gulf carrier. Now his largest shareholder is not only financially sound, but can also cover regions for the larger group where BA and Iberia are not particularly strong—the Middle East and Southeast Asia.

The benefits for Qatar are not equally obvious. But maybe the initiative was the first sign that a new era in airline consolidation is about to begin—transcontinental investments. Even in the medium term they will not lead to full integration, but they could lay the ground work for how large blocks in aviation will look in the future.

In Latin America, the picture is more diverse. With the Latam Group and Avianca, two strong blocks have emerged but are embroiled in internal machinations at the moment. Then there is a small group of relatively successful private airlines such as Copa, Azul and Gol. Copa has had strong links with Continental Airlines and is now a Star Alliance member. Azul will likely integrate into the Star Alliance eventually, but is opting to go the initial public offering route at this point. And Gol has attracted small minority investments from Delta (2.93%) and Air France-KLM (1.5%) that are intended to keep its options open. None of the three are likely to be the object of consolidation efforts anytime soon.

A third group of airlines includes carriers such as Aerolineas Argentinas or LBA Airlines (Venezuela) that are either government-owned or too small—either factor makes them irrelevant for any significant consolidation efforts for now.

So consolidation continues to be elastic, expanding and contracting with the market (and political) forces.

Alitalia was rescued by Etihad Airways, which now holds 49% of the carrier.

KEITH GASKELL

Building Blocks

For Virgin Australia, airline takeovers add new capabilities

JOHN ADLARD/AIRLINERS GALLERY.COM

Adrian Schofield Auckland

Airlines find many reasons for merging with rivals, such as scale advantage, cost synergy, and filling geographic network gaps. However, Virgin Australia provides an example of another kind of merger rationale, acquiring carriers with the specific business models it needs to become a force in new market segments.

Virgin purchased low-cost carrier (LCC) Tigerair Australia to compete head-to-head with Qantas Group LCC Jetstar, and it bought out regional airline Skywest to help build a turboprop network and also become a player in the lucrative charter sector. These moves reflect Virgin's goal of broadening its competitive scope, which has also seen it link with overseas airline partners to tackle Qantas in international and corporate markets.

There was some irony in Virgin Australia's foray into the LCC sector. After all, it started out as low-cost Virgin Blue, before opting to position itself as more of a full-service airline. This shift exposed it to Jetstar at the low end of the price spectrum, an issue Virgin looked to fix by purchasing the Australian Tigerair franchise rather than setting up its own LCC from scratch.

In July 2013, Virgin Australia bought a 60% share in Tigerair Australia from its Singapore-based parent, Tiger Airways Holdings. It later struck a deal to purchase the remaining shares, gaining full control of Tigerair and its fleet of 13 Airbus A320s in October 2014.

This was clearly a strategic positioning move that would not help Virgin's bottom line for some time. Tigerair Australia was still rebuilding after a lengthy grounding by Australian safety regulators, and its financial losses had been dragging down parent Tiger Airways Holdings.

Virgin Australia CEO John Borghetti emphasized that Tigerair would remain a separate carrier and not codeshare with Virgin. In this manner, the two brands would be kept entirely separate to compete in their own market segments. Tigerair also has its own management structure.

But, while they do not codeshare, there are still cost synergies between the two carriers that have helped Tigerair. In addition, there has been some network realignment to ensure that both airlines are serving the types of routes that best fit their business models—an approach also taken by Qantas and Jetstar.

While the main value of Tigerair is strategic, Virgin obviously does not want Tigerair hurting its own financial performance in the long-term. So it is aiming to turn around its subsidiary in relatively short order.

Borghetti initially set a target of returning Tigerair to breakeven by the end of its 2017 fiscal year. However, last year he revised the breakeven target to the end of fiscal 2016. In a recent update, Borghetti said Tigerair is on track to achieve this goal, and may even reach it sooner. Results for the December quarter certainly support his optimism, with Tigerair reporting its first quarterly underlying profit in four years.

When Virgin Australia bought the Tigerair stake, Borghetti said the plan was to expand the LCC's fleet to up to 35 aircraft by 2018. But since then, the carrier has backed away from growth projections and has not committed to a timetable.

Virgin Australia's Tigerair subsidiary gives it access to the low-cost market.

Tigerair Australia currently only operates domestically, although that may change. Borghetti has stated his intention to bring Tigerair to international routes, without giving any detail about where or when this may occur.

Virgin Australia announced its intention to purchase 100% of Perth-based Skywest Airlines on Oct. 30, 2012, capping earlier steps it had taken to bring Skywest into the fold.

The larger carrier formed a partnership with Skywest in 2011, under which Skywest would perform turboprop flying on behalf of Virgin with a new fleet of ATR 72s leased by Virgin from a third-party lessor. Virgin then bought 10% of Skywest in April 2012, followed by the deal six months later for the remainder of the shares.

Virgin Australia had previously operated a limited regional network with Embraer 170 and 190 jets, but the Skywest deals gave it the turboprop operation it wanted to compete effectively with the QantasLink regional service. Aside from the ATRs, Skywest also had other turboprops and small regional jets—and even a couple of Airbus A320s—that were used for regional flights and charter work.

The Skywest aircraft have now been brought under the banner of Virgin Australia Regional Airlines. The ATRs are used exclusively in the east coast regional network, while the other aircraft are used in Western Australia.

While Skywest was already a partner, taking over the carrier gave Virgin greater control of the regional operation. Another major benefit was gaining the aircraft and expertise in the lucrative Western Australia charter business.

As with its regional services, Virgin already operated limited charter flying, but this was a sector in which it wanted to grow and compete more vigorously. It now has valuable contracts for the fly-in, fly-out operations that support mining operations. The carrier uses former Skywest aircraft—including the two A320s—and also has the flexibility to use mainline aircraft for charter work when required.

Not Too Close

Air China and Cathay Pacific cooperate little, despite cross-shareholdings

Bradley Perrett Beijing

It was supposed to be a "historic and far-reaching deal that will create a formidable airline grouping with enormous potential in the world's most exciting and dynamic aviation market." But nine years after the decision to mix the ownership of Air China and Cathay Pacific Airways, there is little sign of a grouping, formidable or otherwise.

Both sides enjoy continuing benefits from the relationship, in which Air China holds 30% of shares in Cathay Pacific, which owns about 18% of Air China. From the beginning of the relationship in 2006, an obvious advantage for Air China was the chance to learn a management trick or two from its new partner. Air China was and is the most internationally focused mainland carrier; Cathay was and is admired for strong management of a large international business.

Cathay's great gain from the cross-shareholding deal was made at the outset: It secured control of the smaller Hong Kong Dragon Airlines, which trades as Dragonair. Among its short- and medium-haul routes, those connecting Hong Kong with mainland cities are crucial in keeping Cathay in its unofficial role as a Chinese gateway airline.

But more was expected by such leaders as then-Air China Chairman Li Jiaxiang—now chief of the Civil Aviation Administration of China—and Christopher Pratt, who was chairman of Cathay major shareholder Swire Pacific when he predicted a "formidable airline grouping." Analysts were also enthusiastic, then and in 2008, when the cross-shareholdings were increased to current levels.

After nine years, the carriers remain members of different airline alliances, Air China in Star and Cathay in Oneworld. Operationally, their cooperation is surprisingly modest. For example, they codeshare on Hong Kong flights to and from Beijing, Tianjin, Chengdu and Chongqing in China. The partnership led to speculation that Cathay would leave Oneworld, but there is no strong sign that it will—and if it ever does, Air China's membership in Star may have little to do with the decision.

"It is not just that they are in different alliances," says analyst K. Ajith of Singaporean brokerage UOB Kay Hian. "They are competitors." Ajith suspects that one motivation for the cross-ownership has been to ensure that the Chinese government has some say over Cathay, the Chinese airline with the strongest international performance.

Cross-Share Chinese Airlines
How Their Fleets Compare

	Air China	Cathay Pacific	Dragonair
Airbus			
A319	30		
A320	38		15
A321	49		8
A330-200	30		
A330-300	19	40	18
A340-300		11	
Boeing			
737-700	20		
737-800	99		
747-400	4	6	
747-8	4		
757-200	1		
777-200ER	10	5	
777-300		8	
777-300ER	20	47	

Source: Aviation Week data

Air China has long had a reputation as the best managed of the central government's carriers, even if none is considered an admirably run business by global standards. Air China's management performance is widely regarded as having improved in the past few years. The opportunity to send people to Cathay for training and experience has probably supported that, Ajith says, though it is hard to say where Air China would be if it had not been able to draw on its Hong Kong partner.

The gains may have been considerable, says a Chinese airline industry consultant, a former Air China manager who asked not to be named. Air China has sent not just upper managers to learn from Cathay, notes the consultant. People holding frontline jobs have also had the advantage of exposure to the Hong Kong airline. Air China has partly modeled its frequent-flier program on Cathay's.

Mainland competition for Cathay, including pressure from Air China, is increasing. The government has told its big airlines to expand their international businesses, and they are doing so. While foreign carriers must suffer, the non-mainland Chinese airline with the most to lose is Cathay.

Air China this year is increasing frequencies to U.S. and European destinations and opening intercontinental routes to Johannesburg; Montreal; Havana; Melbourne, Australia; Auckland, New Zealand; and Addis Ababa, Ethiopia. Hainan Airlines is making a big push to enlarge its North American business. In these circumstances, Cathay can only lose market share, although it could still turn out to hold a narrower slice of a rapidly expanding pie, thanks to the strength of travel to and from China.

Still, the mainland airlines have a long way to go. In 2013, Cathay's international connections—city pairs linked with a single change of flights—were more than twice as numerous as those of all three of the big mainland carriers put together, says Ajith. A comparison of the fleets of Air China and Cathay shows the enduring narrowbody and thus domestic focus of even the mainland carrier that is most expected to be seen abroad (see table).

This points to another factor behind the weakness of the connection between Air China and Cathay, even after almost a decade. In 2006, the managers of the state airline may have earnestly planned to build a much larger international business by studying Cathay's methods. But, at least until recently, Chinese state airlines have, year after year, found more reliable growth and faster profits in the mainland's burgeoning domestic market—one they understand and which is largely free from highly experienced, high-quality competitors such as Cathay.

Medium Contender

Airbus H160 emerges with features designed to challenge AgustaWestland's AW139

Tony Osborne **Marseille, France, and London**

After four years under a veil of secrecy, Airbus Helicopters has unveiled its X4 helicopter, but it is not what the community expected.

When former Eurocopter CEO Lutz Bertling first described the aircraft in 2011, he said it would represent a "different way of flying an aircraft," propelling it into a new generation with a radical new cockpit and fly-by-wire controls. But without those elements, the X4—now called the H160—is about halfway there, introducing new technologies that are more evolutionary than revolutionary.

The H160 is Airbus Helicopters' €1 billion ($1.12 billion) gamble to try to retake a firm hold on a market long monopolized by AgustaWestland. But while the aircraft's sleek design harks back to the AS365 Dauphin, which the H160 ultimately will replace, it is also supposed to represent a substantial change in direction for Airbus Helicopters, with new development processes and production techniques benchmarked against those of its colleagues building airliners down the road in Toulouse.

Airbus Helicopters is pitching the twin-engine H160 for the medium helicopter market, currently dominated by AgustaWestland's AW139 and, to a lesser extent, the Sikorsky S-76 and Bell 412. Airbus wants the H160 to appeal to the oil-and-gas support mission, search-and-rescue (SAR) operators, the emergency medical service community and corporate and VIP transport customers.

On one tank of fuel, the H160 will be able to carry 12 passengers to an oil platform 120 nm offshore, complete a missed approach and return to land. Cruise speed will be around 160 kt. and maximum takeoff weight 5.5-6 metric tons. However, the company believes it can do all of this with an empty weight 1 ton lighter than the AW139 and improve fuel economy and direct operating costs by 15-20%.

"The key to this helicopter is efficiency," says Aurelie Gensolen, marketing manager for the H160 program. "Like we did with the EC175, we are delivering an aircraft with the same level of performance as the AW189, but with a weight of 1 ton less."

Key to the weight savings is extensive use of new materials and technologies—Airbus has taken out 68 patents on the H160 alone. Composites figure widely in the aircraft, with a carbon-fiber airframe produced in-house at facilities in Germany, while the tail boom and tail rotor housing are built by Daher-Socata.

Composite Blue Edge blades, distinguishable by their hockey-stick-shaped tips, were revealed by the manufacturer in 2010 and have been flying since 2007, but the H160 represents the first use of this technology in an Airbus product. Improved since their public debut, the blades have been designed to reduce blade-vortex interactions and cut external noise by 3-4 db. But they also have improved aircraft performance. Engineers say their use on the H160 delivers an extra 100 kg (220 lb.) of payload over current-generation composite blades. They are fitted to a Spheriflex main rotorhead made from composite thermoplastics.

Using an idea first adopted on Sikorsky's RAH-66 Comanche, the H160's fenestron shrouded anti-torque system is canted by 12 deg., which improves lift performance and allows the helicopter to carry an additional 40 kg of payload, compared to the standard configuration. While canted tail rotors are fairly common on platforms from other manufacturers, Airbus introduced the feature on the EC175, and it is now likely to become commonplace on Airbus products.

Combined use of the five-blade main

AIRBUS HELICOPTERS

Airbus Helicopters unveiled an H160 mock-up March 3, but the first prototype is close to first flight in France.

Airbus Helicopters H160 Specifications

Maximum Seating	12 + two crew
Maximum Takeoff Weight	5.5-6 metric tons
Cruise Speed	160 kt.
Powerplant	Two 1,100-1,300-shp Turbomeca Arrano 1As

Source: Airbus Helicopters

rotor with the fenestron, along with the separation of the gearbox from the main structure, means there is no need for a heavy active vibration-control system.

Under the tail boom, the biplane-configuration horizontal stabilizer is another unusual feature that has been designed to improve the H160's stability at low speeds. Under the cabin floor, there are no hydraulic components. Instead, Airbus has opted for electrical landing gear actuation.

Above the cabin and taking lessons from the gearbox issues that affected the EC225, engineers designed a simplified main gearbox, incorporating redundancy for the oil pumps by adding a second independent system within the gearbox itself. In the event of failure of one, the other can continue to provide the necessary lubrication and eliminate the need for an emergency system. Meanwhile, thermal effects caused by friction between components have been countered by lowering the velocity using reduction gearing, limiting the potential for cracks and fatigue. To prove the concept, engineers built a gearbox and then 3-D-printed a transparent gearbox case. They then ran the gearbox to see how the oil would be distributed.

Despite initial plans for two engine options, Airbus has decided to go with Turbomeca's Arrano 1A engine, shelving the Pratt & Whitney Canada (P&WC) PW210E partly because it does not deliver the required levels of power and also because the addition of the second engine increases complexity and cost.

In the cockpit, pilots will find the Helionix avionics suite, which is already installed on the EC145 T2 and EC175 helicopters. Flight information will be displayed on four 6 X 8-in. multifunction displays that can be manipulated by touchscreen or with a cursor.

A Health and Usage Monitoring Systems (HUMS) will be installed as standard on every H160, but because of its wide range of missions, Airbus is developing a series of tailored options so customers with just one helicopter can benefit from the system, a capability that has only been fully appreciated by those operating larger numbers of rotorcraft.

"We are trying to democratize the use of HUMS," says Bernard Fujarski, senior vice president and head of the X4/H160 program. "This is important because there are all types of operational segments that the H160 will be used in."

The H160 will transfer its HUMS data wirelessly. Basic customers will be able to check exceedances on a tablet device that will give the operator a "go, no-go" on the measured components, while larger operators will be able to download all the HUMS data from the helicopter. Eventually, Airbus wants to be able to transmit exceedance data in-flight so engineers can be ready to begin work once the rotorcraft lands.

Airbus Helicopters has invested in new infrastructure to help mature H160 design and speed its development

Compared to other helicopters from Eurocopter and its predecessors, significant work is being undertaken on test rigs with the aim of maturing the design and accelerating the development process. Benchmarking itself against Airbus at Toulouse and the speed and progress of the development of the A350 airliner, Airbus Helicopters has invested in new infrastructure to support this transformation. A huge €10 million concrete whirl tower has been built at the Marignane plant so all the H160's dynamic components can be tested there on an iron bird called Dynamic Helicopter Zero (DHC0). Testing of DHC0 is due to begin in March.

Meanwhile, the complex electronic systems onboard the H160 are being tested on a second rig called System Helicopter Zero (SHC0) in a building nearby. All of the helicopter systems are being wired on the SHC0 as they would be on the real rotorcraft. Since the rig entered operation in January 2014, the team has tested the majority of systems needed for a first flight and has troubleshot some 500 software snags, including production and compatibility issues.

These efforts are part of a drive to ensure reliability and availability the moment the helicopter enters service with customers.

The H160 flight-test program could begin as early as April or May. Three prototypes, PT1/2/3, will be used along with pre-production PS1.

The company will begin taking orders in 2016, and the first deliveries planned for 2018.

Airbus wants to capture around 40% of the medium market, but it will be up against some stiff competition.

AgustaWestland's AW139 has virtually monopolized the medium market for almost a decade. Around 750 helicopters are in service, and deliveries should exceed the 1,000 mark in 2018. Its success comes from bringing new technology into a market that had lacked innovation for many years.

Airbus Helicopters engineers are now beginning to design the equipment packages needed for other missions. A SAR mission-equipped helicopter would feature an electro-optical camera under the nose, rescue hoist fitted to the starboard side and mission console in the cabin. Airbus also envisions a military version—H160M—but it has not formally launched such a program.

Meanwhile, the future of the AS365 Dauphin and EC155 are less clear. The two types will remain in production at least until 2018. But the EC155 may live on in South Korea if it is selected to form the basis of that country's LCH-LAH (Light Civil Helicopter and the Light Armed Helicopter) program.

What is clear is that the H160 is less of a gamble now than it would have been had it continued on the course set by Bertling. Shortly after his arrival in May 2013, Faury reviewed the X4 program and found that the envisioned technologies were not ready or did not add value for the accompanying weight gain.

The next-generation cockpit had not advanced beyond technology readiness level 5, and while fly-by-wire would have saved a small amount of weight, the additional complexity and cost made it impractical. While the idea of a high-tech, advanced helicopter with a new-generation cockpit might have appealed to corporate and VIP customers, it might have proved a training and maintenance headache for larger operators.

"We are essentially driving the product where our customers expect to see it," Faury says. "Our customers want us to be focused on reliability, availability and safety."

Active Advance

Darpa program leads development of next-generation, all-digital active phased arrays

Graham Warwick Washington

Active arrays have brought new capabilities to military radar and electronic warfare (EW) systems, with increased range and power, agility and sensitivity, reliability and multi-function capability. But they also have brought higher costs and longer timescales for the development of new radars and jammers.

Industry has tackled the cost issue with successive generations of active, electronically scanned arrays (AESA), the latest introducing gallium-arsenide semiconductor technology for increased power and efficiency. But there is a problem: Array development is not moving fast enough to take advantage of advances in commercial electronics technology.

Pentagon advanced research agency Darpa's Arrays at Commercial Timescales (ACT) program aims to reduce the non-recurring expense of developing a phased array, often 40% of the cost, and enable the rapid insertion of new technology. "Current arrays are exquisite, highly customized designs with very long development timelines. With the rapid pace of commercial development, we struggle to deploy state-of-the-art electronics in phased arrays," says ACT program manager Troy Olsson.

DARPA

ACT common module mounts directly to array to provide digital beam-forming at each element.

ACT has set out to change the architecture of AESAs by making them more digital, enabling common electronics to be reused across a range of arrays to reduce costs and for those electronics to be updated rapidly with the latest commercial technology. ACT is developing arrays that can be reconfigured inflight across frequency bands and where characteristics such as polarization can be changed in real time.

"Moving to digital arrays gives us the ability to have a software-defined RF [radio-frequency] sensor where we can digitally control every radiating element," says Bill Phillips, director of advanced technology at Northrop Grumman Electronic Systems. "For many years, the vision of elemental digital arrays was unachievable; the device technology was not ready. Commercial investment in system-on-chip technology has made wide-band digital elemental AESAs feasible."

AESAs form and steer beams electronically by shifting the phase at each radiating element in the array. Conventional phased arrays can form and steer only one beam at a time, but can switch between beams so quickly, it seems almost instantaneous. This allows multiple modes to be time-interleaved. With ACT, an AESA could digitally generate multiple simultaneous beams for different purposes, from different parts of the array.

"Arrays will be capable of more things because of digital beam-forming," says Olsson. "A digital array can form as many beams as the digital signal processing allows. It can simultaneously point many beams in multiple directions, and also point holes in certain directions. That is not our reason for pursuing ACT, but it is a benefit of the architecture."

While most operational AESAs have analog beam-forming, there is a trend to move digital processing closer to the face of the array to reduce cost and increase

Eagle Rebirth

USAF finally embarks on programs to keep F-15 in the fight, despite advancing defenses

Amy Butler Washington

The digital revolution is finally catching up with one of the U.S. Air Force's older combat jets.

Long ignored by a leadership determined to focus its resources on the stealthy F-22 Raptor and F-35 Joint Strike Fighter, reality is forcing the service to start spending heavily on its aging F-15, disparaged at times by USAF officials as an inferior aircraft. The air-combat F-15C Eagle and ground-attack F-15E Strike Eagle will be undergoing costly makeovers to keep them operationally relevant until 2040.

Core to the F-15's revival are two key developments: a digital electronic warfare self-protection system geared against advanced air defenses Russia has developed and is selling globally; and an infrared search-and-track system to allow the aircraft to better spot airborne threats at long distances.

Only a decade ago, the Air Force was determined to spend major combat funding only on fifth-generation aircraft in hopes of swiftly shifting to an all-stealth fighter fleet. Yet the harsh reality of having only 183 of the twin-engine, air-superiority F-22s purchased, coupled with the more than five-year delay for the F-35's introduction into service (and a slower pace of fielding) has forced the service's hand. So billions are being poured back into the Eagle and Strike Eagle to keep them in the fight as well.

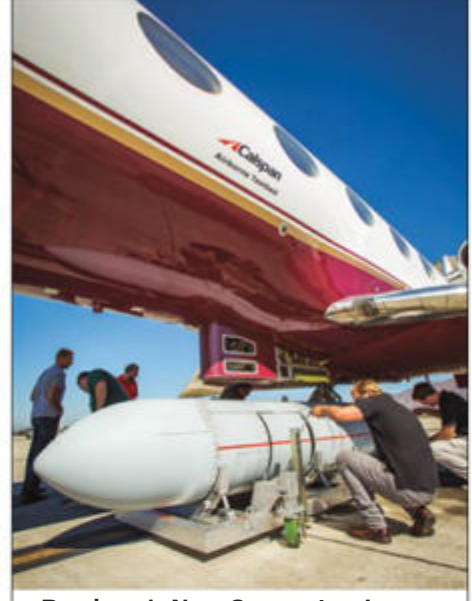
flexibility. Some of the latest AESAs now in development are digital at the subarray level, but ACT is pushing the technology all the way to the array element.

The program has two technical areas. TA1 is focused on digitizing the receiver/exciter and beam-forming, and creating a common module that can be developed once and reused across different arrays ranging from UHF to K_u-band. TA2 is focused on the radiating element that gives an AESA its "personality" as a radar or jammer, and on making it reconfigurable.

The specific frequency, polarization, performance and range of steering angle are frozen into the design of a radiator. "The size, shape and how it is fed sets its performance," says Steve Bernstein, senior technical fellow for advanced technology programs at Raytheon. "ACT is taking a static piece of the system and making it tunable and adjustable as the mission changes."

When electronically scanned arrays were first developed, they were passive with one power amplifier and one low-noise amplifier each. Beam-forming was analog. AESAs introduced semiconductor technology that took the centralized amplifiers and distributed them to transmit/receive (T/R) modules at every element in the array. "In a natural evolution, ACT takes the centralized receiver/exciter module and decentralizes it, one at every element," says Olsson.

Using the ACT architecture, an AESA would comprise the reusable common modules, reconfigurable radiator and, between them, simplified T/R modules to amplify the transmitted and received signals. ACT is focused on developing



NORTHROP GRUMMAN

Raytheon's Next Generation Jammer pod for U.S. Navy uses AESAs with gallium-nitride power electronics.

the common module and radiator, while other programs are working on reducing the cost of T/R modules, says Bernstein.

"ACT is developing a common module that includes much of what is in a traditional T/R module, and also integrating the receiver/exciter and beam-forming into a single module," says Phillips. "The common module breaks the paradigm of system classifications. You no longer have an array just for radar or EW. You now have a software-defined sensor that can be a radar in one mode and support EW in another."

Digitizing an RF array requires analog-to-digital (A/D) and digital-to-analog (D/A) converters with high sample rates and dynamic ranges. "There have been tremendous advances in sample rate and dynamic range from fine-line CMOS [complementary metal oxide semiconductor] processes," says Olsson, citing RF sample rates in the 60-gbps range. "Power consumption has reduced tremendously," he says. Another 40-50% decrease is foreseen when the common-module electronics move to 14- from 32-nanometer nodes in the next phase of ACT.

Conventionally, RF is reduced to an intermediate frequency before conversion to digital from analog, but ACT technology enables direct RF sampling, which eliminates circuitry. "The key is commercial system-on-chip technology. You can have many functions of a chip and eliminate many components in a system," says Phillips. "Traditionally, there were A/D converter chips and D/A chips. Now you can do both and have a digital receiver/waveform-generator on a single chip."

The 24-month Phase 1 of ACT, TA1, has been underway since June 2014, following a six-month Phase 0 study. Boeing, Northrop Grumman and Rockwell Collins are designing and building common modules for testing late this year. In Phase 2, to begin in June 2016, industry will have to prove the common modules can be upgraded rapidly with the latest commercial technology, moving to 14- from 32-nanometer microelectronics within 15 months.

"TA2 is a much more fundamental development effort than the common module, which uses a new architecture, but [with] commercial processes and well-understood materials," says Olsson. The two areas are independent and are not planned to be brought together within ACT because of the relative technology readiness levels they will achieve over the program's duration.

In a clear sign the F-15 will be central to conflict, the aircraft also is set to receive a gateway to allow it to communicate with its newer cousins.

The plan to upgrade the Tactical Electronic Warfare System (TEWS) on up to 413 F-15Cs and Es will cost $7.6 billion to implement. Boeing, the F-15's manufacturer, is managing the so-called Eagle Passive/Active Warning Survivability System (Epawss) program as prime contractor. A competition is underway among major electronic warfare providers—likely to include Northrop Grumman, Raytheon and, possibly, BAE Systems—with a source selection expected in May, says Boeing spokesman Randy Jackson. The company expects its contract for the upgrade in August, he adds.

Today's TEWS self-protection suite is "based on 1970s technology and is functionally obsolete and costly to sustain and adapt to future threats," according to Air Force acquisition officials. Air Combat Command (ACC) officials say the repair cost for TEWS units has increased by 259% in the last decade.

Epawss installations are slated to begin in fiscal 2017 to support development and testing work. Initial fielding is slated beyond 2020, the acquisition officials say. Epawss is scheduled to include an internal digital radar warning receiver, a jammer, upgraded chaff and flare, and an external fiber-optic towed decoy, according to ACC.

The upgraded system should provide increased protection by detecting more threats more quickly, and providing pilots with more options to use in defeating them. Saudi Arabia also is buying F-15s with a digital electronic warfare system, which is already in development.

Digitization on the battlefield also is driving the USAF's second major F-15 upgrade. The proliferation of Digital Radio Frequency Memory (DRFM) jammers is a key driver behind the push for an infrared search-and-track (IRST) sensor for the Eagle, according to John McLaughlin, deputy F-15 program element monitor at ACC.

DRFM systems are able to quickly

analyze and replicate signals and jam them, rendering traditional situational awareness systems, such as radar, inadequate. That is driving the Air Force to use sensors "out of band," as officers say, to detect and identify airborne targets.

For the F-15Cs, that means providing an ability to target an enemy outside X-band where the plane's radar operates. "A long-wave [IRST] will give the F-15C an out-of-X-band solution to counter the threat and restore a dominant air-to-air kill chain," McLaughlin says. As a further sign the Air Force is concerned about the jamming threat, an "out-of-band" sensor is also on the wish list for the F-22, according to ACC briefings.

These infrared sensors have long been favored by Russia and other militaries, but are being adopted by the Pentagon only gradually.

LOCKHEED MARTIN

Lockheed Martin is building on the U.S. Navy's IRST21 sensor for its long-wave infrared search-and-track Legion pod for the F-15C.

Because it lacks stealth, the F-15C and F-15E are unlikely to operate in environments the Pentagon describes as "anti-access, area-denied," a euphemism for the most heavily defended airspace, often protected with systems designed and built in Russia or China. That is the job of the stealthy F-22, which is what is driving the desire to feed it IRST data.

To date, the Navy's long-retired F-14 has been the only modern U.S. fighter to carry a long-wave IR sensor. That sensor allows the operator to locate enemy formations—potentially distinguishing their numbers and type—beyond visual range, allowing for extra time to engage. Using yet-to-be-developed gateways, such data also could be transferred covertly to stealthy platforms forward in the fight.

The Navy, the last U.S. customer slated to introduce the F-35 into service, by February 2019, already has embarked on plans to develop its own IRST for its Boeing F/A-18E/F Super Hornet, selecting Lockheed Martin's IRST21 sensor. The service recently approved the system for low-rate production, and fielding of 170 units should begin in 2017, says Lockheed Martin spokeswoman Melissa Hilliard.

The Air Force is following in the Navy's footsteps in fielding an IRST sensor for all F-15Cs. Once teamed on a joint IRST program for the F/A-18E/F and F-15, the two services parted ways in 2010, leaving the Air Force on its own and delaying installation until now, McLaughlin says.

The IRST project has been shifted under the umbrella of a larger requirement to field a communications gateway pod, called the Multi-Domain Adaptable Processing System (MAPS), for the F-15C. It should provide a tie to the F-22's covert inflight data link and the F-35's multifunction advanced data link. The operational concept calls for stealthy aircraft to fly closer to threats—collecting intelligence—and transmitting the data to fourth-generation jets that can remain safely outside enemy defenses.

ACC still is studying the right mix of IRST-only pods versus those with the sensor and the MAPS communications terminal, McLaughlin says.

MAPS provides a Band-Aid in the USAF's communications architecture because the F-22s were designed to communicate only with other Raptors via a low-probability-of-intercept/low-probability-of-detection link. When the twin-engine air-superiority fighter was designed, planners expected hundreds to enter service, but with only 183, the fleet is ill-prepared to address some scenarios without the help of legacy aircraft. The F-22 also lacks the ability to collaborate with the F-35 covertly.

The first four MAPS pods—carrying only the communications gateway—are slated to be fielded in fiscal year 2019 with the "IRST-only" version to follow in fiscal 2021, four years after the Navy is slated to field its IRST21. All MAPS pods carrying the gateway are expected to be in service by 2021.

Lockheed Martin has built its Legion pod for the F-15C on the IRST21 sensor, says Don Bolling, a business development director there. The 16-in.-dia. pod is slated to include the long-wavelength-infrared sensor as well as some passive radar frequency signal-detection capabilities. Like the company's Sniper targeting pod, Legion is designed to seamlessly "plug" into its host aircraft on the centerline under the F-15C's fuselage. It is also supposed to feature a proprietary "pod-to-pod" datalink that would allow the threat picture to be shared with others.

Bolling says he expects competition from Raytheon and Northrop Grumman; Boeing declined to identify the participations in the IRST competition.

MAPS, not formally a program yet, would proceed separately, according to Air Force acquisition officials. It will use lessons from the quick-reaction Talon Hate pod program developed by the Air Force to satisfy an urgent need in the Pacific. Talon Hate will include IRST and a gateway, "providing valuable feedback for the MAPS program," McLaughlin said. It will provide a fifth-to-fourth capability only with the F-22 and F-15.

Boeing is building four Talon Hate pods, which are slated for delivery this fall. It is unclear when they will be fielded, as the Air Force is managing the modifications needed to the F-15Cs. Boeing's original contract for the pods cost $134.6 million, though the program cost is expected to be higher. Air Force spokeswoman said a cost estimate upon completion is not available.

I See You

Counterstealth technologies near service worldwide

BILL SWEETMAN/AW&ST

Along with the multi-radar, truck-mounted 55Zh6M, NNIRT is offering the trailered, single-unit 55Zh6UME with VHF and UHF antennas mounted back-to-back.

Bill Sweetman Washington

Counterstealth technologies, intended to reduce the effectiveness of radar cross-section (RCS) reduction measures, are proliferating worldwide. Since 2013, multiple new programs have been revealed, producers of radar and infrared search and track (IRST) systems have been more ready to claim counterstealth capability, and some operators—notably the U.S. Navy—have openly conceded that stealth technology is being challenged.

These new systems are designed from the outset for sensor fusion—when different sensors detect and track the same target, the track and identification data are merged automatically. This is intended to overcome a critical problem in engaging stealth targets: Even if the target is detected, the "kill chain" by which a target is tracked, identified and engaged by a weapon can still be broken if any sensor in the chain cannot pick the target up.

The fact that some stealth configurations may be much less effective against very-high-frequency (VHF) radars than against higher-frequency systems is a matter of electromagnetic physics. A declassified 1985 CIA report correctly predicted that the Soviet Union's first major counterstealth effort would be to develop new VHF radars that would reduce the disadvantages of long wavelengths: lack of mobility, poor resolution and susceptibility to clutter. Despite the breakup of the Soviet Union, the 55Zh6UE Nebo-U, designed by the Nizhny-Novgorod Research Institute of Radio Engineering (NNIIRT), entered service in the 1990s as the first three-dimensional Russian VHF radar. NNIRT subsequently prototyped the first VHF active electronically scanned array (AESA) systems.

VHF AESA technology has entered production as part of the 55Zh6M Nebo-M multiband radar complex, which passed State tests in 2011 and is in production for Russian air defense forces against a 100-system order. The Nebo-M includes three truck-mounted radar systems, all of them AESAs: the VHF RLM-M, the RLM-D in L-band (UHF) and the S/X-band RLM-S. (Russian documentation describes them as metric, decimetric and centimetric—that is, each differs from the next by an order of magnitude in frequency.) Each of the radars is equipped with the Orientir location system, comprising three Glonass satellite navigation receivers on a fixed frame, and they are connected via wireless or cable datalink to a ground control vehicle.

One of the classic drawbacks of VHF is slow scan rate. With the RLM-M, electronic scanning is superimposed on mechanical scanning. The radar can scan a 120-deg. sector mechanically, maintaining continuous track through all but the outer 15-deg. sectors. Within the scan area, the scan is virtually instantaneous, allowing energy to be focused on any possible target. It retains the basic advantages of VHF: NNIRT says that the Chinese DF-15 short-range ballistic missile has a 0.002 m2 RCS in X-band, but is 0.6 m2 in VHF.

The principle behind Nebo-M is the fusion of data from the three radars to create a robust kill chain. The VHF system performs initial detection and cues the UHF radar, which in turn can cue the X-band RLM-S. The Orientir system provides accurate azimuth data (which Glonass/GPS on its own does not support), and makes it possible for the three signals to be combined into a single target picture.

The higher-frequency radars are more accurate than VHF, and can concentrate energy on a target to make successful detection and tracking more likely. Using "stop and stare" modes, where the antenna rotation stops and the radar scans electronically over a 90-deg. sector, puts four times as much energy on target as continuous rotation and increases range by 40%.

Saab's work on its new Giraffe 4A/8A S-band radars points to ways in which AESA technology and advanced processing improve high-band performance against small targets. Module technology is important, maximizing the AESA's advantages in terms of signal-to-noise ratio. The goal is signal "purity" where most of the energy is concentrated close to the nominal design frequency, which makes it possible to detect very small Doppler shifts in returns from moving targets.

New processing technologies include "multiple hypothesis" tracking in which weak returns are analyzed over time and either declared as tracks or discarded based on their behavior. China is taking a similar approach to Russia, as seen at last November's Zhuhai air show. Newcomers included the JY-27A Skywatch-V, a large-scale VHF AESA closely comparable to Russia's RLM-M, developed by East China Research Institute of Electronic Engineering (Ecriee), part of the China Electronics Technology Corp. (CTEC). Two alternative UHF AESAs and a YLC-2V S-band passive electronically scanned array radar were also on show.

CETC exhibits indicated a focus on combining active and passive detection systems, including the flight-line display of a large-area directional, wideband passive receiver system identified as YLC-20. It appears to be used as an adjunct to the CETC DWL-002, which is a three-station passive coher-

ent location (PCL) system similar to the Czech ERA Vera series, using time difference of arrival processing to locate and track targets. Also shown on a wall chart was the JY-50 "passive radar," which operates in the VHF band.

Previous PCL systems, including Vera, are designed to exploit active emissions from the target. However, by teaming PCL and other passive receivers with active radars, the defender creates bistatic and multistatic detection systems, which may reduce the effectiveness of RCS-reduction measures that are primarily monostatic. For instance, highly swept leading edges are designed to deflect radar signals away from the source, but can create spikes detectable by multistatic systems.

Older and smaller VHF radars such as the NNIRTI's 1970s-era P-18 are being upgraded by at least five teams: Retia in Czech Republic, Arzenal in Hungary, Ukraine's Aerotechnica, and organizations in Belorussia and Russia. The Chinese navy has retained VHF radar on its newest air warfare destroyers such as the Type 52C Luyang II and Type 52D Luyang III. The possibility of a more modern VHF radar appearing on the new, larger Type 055 destroyer cannot be ruled out.

The challenge to stealth posed by lower-frequency radars and other detection means has been acknowledged at higher levels since 2013. U.S. chief of naval operations Adm. Jonathan Greenert has publicly expressed doubt as to whether stealth platforms constitute a complete answer to the developing anti-access/area-denial (A2/D2) threat, and a January 2014 paper by the Center for a New American Security noted, "One recent analysis argued that there has been a revolution in detecting aircraft with low RCS, while there have not been commensurate enhancements in stealth."

BILL SWEETMAN/AW&ST

The CETC JY-27A Skywatch-V, China's first VHF AESA, is in production for Chinese air defense units.

Boeing has promoted the EA-18G Growler's ability to jam in the VHF band, which is built into the current ALQ-99 low-band pod configuration (the most modern part of the system) and the planned Increment 2 of the Next Generation Jammer system. Increment 2 will likely comprise an upgrade to the current pod—the best solution to emerge from an analysis of alternatives conducted in 2012. A contract should be issued in 2017 with initial operational capability in 2024.

A different kind of radar threat is the very-long-wave over-the-horizon (OTH) radar, typified by Australia's Jindalee OTH Radar Network (JORN), Russia's Rezonans-NE, and China's OTH systems. Again, processing is the key to increasing the accuracy and sensitivity of these systems, typified by the Phase 5 upgrade to JORN.

OTH long-wave radars are inherently "counterstealth" because at very long wavelengths that are close to the physical size of the target, conventional radar cross-section measurement and reduction techniques do not apply. Claims by Jindalee's original designers that the radar could detect the B-2 were published in the late 1980s and were taken seriously by the U.S. Air Force. At the time, however, the service could argue that OTH's resolution was so poor that it could not represent the start of a kill chain. Today, however, that low resolution can be mitigated by networking multiple radars, and by using OTH-B to cue high-resolution sensors.

Outside the radio-frequency band, the U.S. Air Force (*AW&ST* Sept. 22, 2014, p. 42) is the latest convert to the capabilities of IRST. The U.S. Navy's IRST for the Super Hornet, installed in a modified centerline fuel tank, was approved for low-rate initial production in February, following 2014 tests of an engineering development model system, and the Block I version is due to reach initial operational capability in fiscal 2018. Block I uses the same Lockheed Martin infrared receiver—optics and front end—as is used on F-15Ks in Korea and F-15SGs in Singapore. This subsystem is, in turn, derived from the IRST that was designed in the 1980s for the F-14D.

While the Pentagon's director of operational test and engineering criticized the Navy system's track quality, it has clearly impressed the Air Force enough to overcome its long lack of interest in IRST. The Air Force has also gained experience via its F-16 Aggressor units, which have been flying with IRST pods since 2013. The Navy plans to acquire only 60 Block I sensors, followed by 110 Block II systems with a new front end.

The bulk of Western IRST experience is held by Selex-ES, which is the lead contractor on the Typhoon's Pirate IRST and the supplier of the Skyward-G for Gripen. In the past year, Selex has claimed openly that its IRSTs have been able to detect and track low-RCS targets at subsonic speeds, due to skin friction, heat radiating through the skin from the engine, and the exhaust plume. The U.S. Navy's Greenert underscored this point in Washington in early February, saying that "if something moves fast through the air, disrupts molecules and puts out heat . . . it's going to be detectable."

These detection improvements do not mean the end of stealth, in the view of most industry and government sources, but they do underlie current plans and discussions for the future applications of RCS-reduction and other stealth-related technologies. For example, the long debate over the appropriate level of stealth technology for the U.S. Navy's Unmanned Carrier-Launched Airborne Surveillance and Strike program has revolved around the development of A2/AD threats. The result is the end of a decades-long misapprehension, widely held in professional as well as public circles, that there is no major difference in stealth performance among various low-observable designs.

Just in Time

Korean Air Lines, backed by Airbus, bids for KF-X development

Bradley Perrett

Two days before deadline seems to be an odd time for stitching together a bid to develop an advanced fighter. But that is how much time was left last month when Korean Air Lines Co. secured Airbus as a technical partner for its bid to develop South Korea's KF-X indigenous combat aircraft, even though the program has been a prospect for more than a decade.

Just a few weeks before responding to that second and final deadline on Feb. 24, Korean Air Lines was also negotiating with Boeing. And the South Korean company seems not to have decided to make a run for the program until late last year, when industry officials said it was talking to the two possible foreign partners. Its competitor is Korea Aerospace Industries (KAI), which appears much better prepared and is backed by Lockheed Martin.

The Defense Acquisition Program Administration (DAPA) is due to choose a preferred KF-X airframe contractor this month and confirm the final selection around July. The finance ministry has approved 8.8 trillion won ($7.99 billion) for developing KF-X, but only parliament can appropriate the funds.

Absence of technical detail adds to the impression that the Korean Air Lines offer is somewhat makeshift. The company, whose manufacturing division would undertake the work, says its proposed fighter would be "better than the Eurofighter Typhoon," which some Airbus units helped to develop. The offer is presumably not the KF-X design which the defense ministry's Agency for Defense Development (ADD) has been working on for about a decade and which is the basis of KAI's proposal. If Korean Air Lines had the same plan, there would be no harm in saying so.

Korean Air Lines adds that its KF-X would be free from U.S. export control, which means it can have no major U.S. systems.

The company does not have a final agreement with Airbus on cooperation. That will follow their current memorandum of understanding (MOU) only on confirmation of a win by Korean Air Lines, says the European manufacturer. Sounding more polite than enthusiastic, Airbus explains its participation as providing support to a major customer who asked for help. Korean Air Lines, whose airline division uses Airbus aircraft, did not respond to Aviation Week's inquiries.

Airbus and Korean Air Lines concluded their MOU for the joint bid on Feb. 22. A week prior, the airline had not chosen a powerplant for its proposed fighter, and even now no engine choice has been announced. KAI has not chosen an engine, either, but with more time and a well worked out preliminary design from ADD, it must have gone much further in defining its propulsion requirements. Korean Air Lines is likely to have received only standardized sets of price, terms and specifications from engine suppliers, based on their earlier competitors elsewhere.

Eurojet, owned by Rolls-Royce, MTU, ITP and Avio Aero, says it is working with KAI, Korean Air Lines and Samsung Techwin, the likely manufacturer of the KF-X engine. The promise of freedom from U.S. export licensing suggests Korean Air Lines is not considering the General Electric F414, the only U.S. powerplant of a suitable size for the two-engine fighter.

Indonesia, which was subject to a U.S. arms embargo as recently as 2005 because of human rights violations, has agreed to pay 20% of KF-X development costs; its participation strengthens the argument for a design free from U.S. export control.

Freedom from export control is not known to be in the DAPA requirements. But technical capability of the bidder and price are. If Korean Air Lines can persuade assessors that it is as technically able as KAI, despite having a much smaller engineering organization, then cost and therefore the bid price should be critical. If the proposal is based on the Typhoon, yet somehow presented as a new design, as DAPA requires, then development should be cheaper.

Korean Air Lines agreed to cooperate with Airbus because the DAPA is requiring a foreign company to supply technical assistance, an official of the Korean company tells the Yonhap news wire. "Further discussions will take place later to set details on technological cooperation and investment," that official says.

The South Korean defense ministry proposes to buy 120 KF-Xs. Indonesia has said it would buy 50. With such a small production run for the two home countries, exports are clearly essential to viability.

KAI has been the expected prime contractor for KF-X, because it has a larger engineering organization and far more experience in combat aircraft development than Korean Air Lines. With much help from Lockheed Martin, KAI developed the supersonic T-50 trainer and combat derivatives.

Lockheed Martin is KAI's technical support partner for KF-X because it is required to back the indigenous program in return for an order for 40 F-35 Lightning fighters. If Korean Air Lines/Airbus win, Lockheed Martin would likely be relieved of that responsibility. Doubts about the role of Lockheed Martin contributed to Boeing's decision in January or February to opt out of the bid. For a time, it seemed possible the U.S. company and Airbus would together back the Korean Air Lines bid.

AW&ST ART DEPARTMENT

In 2013 or earlier, Airbus, then known as EADS, proposed a twin-fin version of the Typhoon for KF-X.

Missed Intercept

Arrow 2 failed to hit target in September test

Alon Ben David, Tel Aviv

Israel has been a world pioneer in developing and deploying missile defense systems, but its programs have suffered two setbacks in recent months. And after months of vague statements, Israel has finally acknowledged that its Arrow-2 antiballistic missile system failed a September 2014 intercept test. The Israeli defense ministry also says a December 2014 test of the Arrow-3 system was aborted due to a malfunction in the target missile.

Developed jointly by Israel's Missile Defense Organization and the U.S. Missile Defense Agency (MDA), the system was declared operational in 2000. Ever since, Arrow has undergone constant hardware and software improvements to counter emerging ballistic threats in the region.

During the 17th intercept test of the system, on Sept. 9, the Arrow-2 was launched against a Rafael Defense Systems' Silver Sparrow target missile. It was lofted from an F-15I fighter above the Mediterranean, simulating an Iranian Shahab ballistic missile. The Arrow's radar detected and tracked the incoming target as it flew eastbound and launched the interceptor from the Israeli shore. The Arrow-2 IR sensor acquired the target and navigated to engage it. It flew by the target, initiating the proximity warhead, but it failed to destroy the warhead.

After the test, the Israeli defense ministry and MDA announced that the Arrow-2 had "performed its flight sequence as planned." They added that "the results are being analyzed by program engineers."

Russian radars detected the target missile falling into the Mediterranean some 200 mi. west of the Israeli shore, according to a spokesperson for the Russian defense ministry.

Sensors on the target missile immediately indicated it was not damaged, but Israel's defense ministry only now has confirmed that the system actually failed. "It took us three months to discover what exactly failed in tests," a senior Israeli defense source says.

While the initial U.S.-Israeli announcement stated that the test results "have no effect on the Israeli operational system capability," Aviation Week has learned that measures were taken to fix the problem in Israel's existing arsenal of Arrow-2 interceptors. "Everything was fixed, and this event is behind us," the defense source says. An additional senior source adds, "This is why we conduct tests—to learn about potential problems in our system."

Despite an aborted test of the Arrow-3 missile defense system in December 2014, the Arrow-3 interceptor test was successful early in the year.

U.S. MISSILE DEFENSE AGENCY

The Arrow-2, produced by Israel Aircraft Industries and Boeing, is designed to engage Syrian Scud-type and Iranian Shahab medium-range ballistic missiles in the upper layers of the atmosphere. But fearing that those missiles could one day carry non-conventional warheads, Israel is already developing a higher-tier defense, the Arrow-3, designed to intercept incoming missiles outside the atmosphere, which would provide time for two or three interception attempts against every incoming missile.

After successfully completing two fly-out tests, the Arrow-3 had its first intercept test on Dec. 16. This time, a more sophisticated Sparrow-type target was launched from a greater distance above the Mediterranean. "It was a unique target, generating minimal fragmentation and designed to lower the risk of collateral damage to ships and aircraft traveling in the area," the defense source says.

Using the same Elta Green Pine radar as the Arrow-2, the system detected and tracked the target as it ascended above the atmosphere. When the reentry vehicle was separated from the engine, a malfunction occurred and the test's directors decided to abort and not launch the interceptors. "Conditions were not ripe to conduct the test," an Israeli defense statement said.

Following the "no test," Israel will conduct another interception test of the Arrow-3 this year. It is hoping to achieve initial operational capability in 2016.

Parallel to the Arrow-3, efforts are underway to complete the middle-tier missile defense system, David's Sling. Developed by Rafael and Raytheon, David's Sling is designed to counter short-range ballistic missiles, long-range rockets and cruise missiles. Already tried successfully against numerous types of rockets, the first David's Sling system is expected to be delivered to the Israel air force late this year.

Israel will eventually deploy a four-layer missile defense alignment, with the Arrow-3 as the upper tier, Arrow-2 below that and then David's Sling. The lowest tier will be the combat-proven Iron Dome system, which has been used to counter rocket attacks from Gaza.

Linking Unmanned

Certifiable command-and-control data link within reach for civil unmanned aircraft

UNIVERSITY OF NORTH DAKOTA

A CNPC link will be tested first in the SandShark (inset), and later in the long-range ScanEagle.

NORTHROP GRUMMAN

Graham Warwick Washington

Development of a certifiable data link for command and control of civil unmanned aircraft is entering the final stages, with NASA and Rockwell Collins planning to flight-test a fifth and final generation of prototype waveform this summer.

The avionics manufacturer, meanwhile, is cooperating with the University of North Dakota (UND) on a jointly funded research project to extend testing of the link to larger networks, a wider geographic area, more users and different classes of unmanned aircraft.

Research on the Control and Non-Payload Communications (CNPC) data link is supporting efforts by avionics standards developer RTCA to define a command-and-control (C2) link using C-band and L-band frequency spectrum reserved for unmanned aircraft systems (UAS).

RTCA Special Committee (SC) 228 is developing minimum operational performance standards (MOPS) for the civil-certifiable C2 link. Final requirements for the MOPS are expected this month, allowing Rockwell Collins to begin design of the fifth and final spiral of the CNPC waveform.

"Development and test this summer will provide V&V [verification and validation] of the MOPS being developed by SC 228, by testing the radio against the standard," says John Moore, CNPC principal investigator. Development of the prototype waveform is being funded by the manufacturer and NASA.

RTCA is scheduled to release the draft MOPS for the civil C2 link in July. Following V&V testing, the final performance standard is planned to be released in July 2016. The FAA will then build the MOPS into an avionics certification document, or technical standard order, to be published in the fall of 2017.

Rockwell Collins has been working with NASA on the prototype CNPC waveform since 2011. "When we started, there was no MOPS and no SC 228. Since SC 228 stood up [in 2013] there has been a refinement of data rates, but not a fundamental rebuild. We believe we are close," says Moore.

Flight-testing has involved NASA Beechcraft T-34 and Lockheed S-3 aircraft acting as surrogate UAS, with a ground station controlling them through their autopilots, via the CNPC link, but with safety pilots on board. "Working with UND will give us an operating area to extend testing into broader capabilities," explains Moore.

"We want to instantiate CNPC within larger networks than under the NASA program," says Tom Vogl, project engineer at Rockwell Collins's Advanced Technology Center. "We want to look at performance and other considerations for the radio being deployed on larger scales, including beyond-line-of-sight and broader ground-based architectures."

Deploying CNPC with UND would also make the data link available to the Northern Plains UAS Test Site in North Dakota, one of six FAA-approved sites for civil UAS research. "We would like to have it as an asset within the UAS test site for other entities to use and give us feedback," Vogl says.

The two-year project is being funded by Rockwell Collins and UND, each providing $500,000. "We are taking an incremental approach," says Vogl. "This year, we will do an initial instantiation and work through the logistics with UND and the test site. Next fiscal year, we will build out a larger network and investigate beyond-line-of-sight."

Flights are to begin from Lakota, North Dakota, in June, using the Northrop Grumman SandShark vehicle employed by UND to provide UAS operator training. A larger Insitu ScanEagle may be used later. "Using real UAS will provide fidelity for the system aspects we want to test," says Vogl.

UND plans to install the ground radio on the tower to provide longer line-of-sight range, and work is underway to obtain certificates of authorization from the FAA for the testing. "We have the small SandShark available to us . . . and have access to a couple of ScanEagles at the university that we would like to use," says Doug Olsen, associate director at UND. "ScanEagle has significantly improved range and performance versus a small UAS, but we are still working though the logistics."

So far, flight tests have used a military software-defined radio to host the CNPC waveform, but Rockwell Collins has finalized a cooperative agreement with the FAA to produce a small form-factor radio to fly this summer in the agency's ScanEagle UAS. "NASA has agreed to expand their testing to include this radio," says Vogl.

Key to the CNPC is its narrow bandwidth, which is required to allow multiple civil UAS to share and reuse the spectrum available. The expectation is that up to 10-12 aircraft will share sets of frequencies within a geographic cell.

Light Touch

European, U.S. laser comm suppliers eye Silicon Valley's satellite broadband plans

Amy Svitak Paris and Frank Morring Jr. and Graham Warwick Washington

Satellite Internet startup Teledesic Corp. failed in the late 1990s largely due to technical setbacks. But one of its key vendors—a small German supplier of laser communications technology—has pressed on and could be uniquely poised to support Silicon Valley's renewed interest in space-based global connectivity.

With companies such as Google, OneWeb and LeoSat planning rival constellations of hundreds, or even thousands of low-Earth-orbit (LEO) broadband spacecraft, some of which may utilize laser comm for inter-satellite links, Tesat Spacecom of Backnang, Germany, could see its persistence pay off.

A subsidiary of Airbus Defense and Space, Tesat has spent the past quarter-century maturing high-bandwidth optical communications for inter-satellite transmissions, an effort that is starting to bear fruit: This year, Tesat's first commercial laser communications terminal (LCT) is set to enter operational service under the European Data Relay Service (EDRS). The public-private partnership valued at around €600 million ($643 million) is cofinanced by Airbus, the European Union and the European Space Agency (ESA) and is already delivering very high data-rate, bidirectional relay between remote-sensing satellites in LEO and the ground, via a satellite in geostationary orbit (GEO).

"It started with Teledesic, but the German Aerospace Center DLR and Tesat have stuck with it, and now it's the policy of Germany that laser comm is a core capability in space," says Matthias Motzigemba, head of laser products at Tesat. "We have been taking the different intermediate steps over 25 years to develop the product we have today."

Through EDRS, Tesat has been demonstrating optical links with LEO-to-GEO laser transmissions using an experimental LCT aboard Inmarsat's Alphasat commercial communications satellite and an operational terminal on the European Sentinel-1A synthetic aperture radar spacecraft launched last year. Alphasat then relays the data in K_a-band to the ground.

With their shorter wavelength, laser-based data transmissions offer several advantages over conventional radio frequencies (RF), including the ability to achieve higher data rates than radio signals for the same aperture. Laser terminals tend to be lighter than their RF counterparts, and laser beams require less power for data transmission. Due to the higher efficiency and low beam divergence of a laser, the link is a secure point-to-point connection. Laser optics also eliminate the need to coordinate RF spectrum allocation with regulators.

The downside of laser comm is that the beams cannot penetrate clouds, and transmissions are easily disrupted or terminated by dust or other atmospheric elements, making optical communications better suited to the vacuum of space.

Tesat is now under contract to develop additional LCTs for future Sentinel spacecraft and is producing four per year using its standard 1,064 nanometer wavelength and BPSK modulation. The company is also preparing to launch its first commercial LCTs as hosted payloads on commercial communications spacecraft, starting with EDRS-A on the Eutelsat 9B satellite this year.

Airbus, ESA and the EU also recently finalized plans to fund the completion and launch of a second geostationary data relay payload, EDRS-C, to launch on the Hylas-3 telecommunications satellite owned by Avanti Communications of London.

A third and final commercial LCT node, known as EDRS-B, could be launched in the future to give the system global coverage, although the 22-nation ESA has not funded the effort.

Tesat has also teamed with General Atomics to cofinance a demonstration of ground-to-GEO and aircraft-to-GEO links using Alphasat and an MQ-9 Reaper unmanned aerial vehicle (UAV), with trials planned in 2016 and 2017, respectively.

"We are flying over 65 Predators and Reapers at all times around world. If we bundled up all the data, all the video and [command and control] C2 on those aircraft, that would still be only 40% of the bandwidth that we have on a laser communications terminal," says David Robie, director of electro-optical systems at General Atomics. "That gives you an idea of what the potential is."

The partnership stems from a U.S.-German government initiative in 2008 to test space-based laser links between the U.S. Missile Defense Agency's Near Field Infrared Experiment (Nfire) and Germany's TerraSAR-X radar spacecraft. The long-running experiment—demonstrating the ability of the plat-

SPACE SYSTEMS/LORAL CONCEPT

NASA's Laser Communications Relay Demonstration could fly as soon as 2018.

forms to establish a laser link at a distance of 40,000 km (25,000 mi.) and transmit data at 5.6 gbps—is expected to end this year.

As Europe makes headway in the area of inter-satellite links, NASA is developing new technologies that could bring high-bandwidth laser signals down to Earth. The U.S. space agency sent laser signals from the Moon to Earth with the Lunar Atmosphere and Dust Environment Explorer (Ladee) in 2013 and is preparing to demonstrate a high-bandwidth point-to-point laser-comm link via a hosted payload on a GEO commercial communications satellite.

The Laser Communications Relay Demonstration (LCRD) is to fly on a to-be-determined Space Systems/Loral spacecraft late in 2018 or early 2019, says Donald Cornwell, technology director for NASA's Space Communications and Navigation (SCAN) program office. It will use the same ground stations at White Sands, New Mexico, and Table Mountain, California, used in the Ladee demonstration, upgraded with adaptive optics to permit even faster signaling through the atmosphere.

Despite the challenge of cloud cover and atmospheric interference, that kind of bandwidth has attracted a lot of commercial interest. SCAN received so many responses to a request for information on possible experiments to include in the LCRD payload that "we plan to have something like a guest investigator program on the mission, where industry can come in and try some things," says Cornwell.

Also in the works is an LCRD package for the International Space Station, to gather data that could support the hoped-for commercial infrastructure NASA is trying to foster in LEO in the coming decade. "Once you show that you can master the atmosphere and the pointing and the acquisition and tracking, there's nothing that then says you couldn't launch a system that could do 100 gbps or a terabit per second from the ground up to the sky," he says.

Weather is likewise the elephant in the room whenever Laser Light Communications' plans for an end-to-end satellite system are discussed. But the company has an answer, tied to its plans to be a long-haul telecom carrier that uses space as its medium.

Although Laser Light has yet to secure a major financial backer, the U.K.-based startup plans 8-12 satellites in medium Earth orbit (MEO) and up to 100 ground nodes connected by a lattice of fiber-optic links creating continent-sized wide-area networks. Data will go by laser beam from ground node to satellite, spacecraft to spacecraft, and satellite to ground node with speeds, frequencies and waveforms compatible with terrestrial fiber-optic networks.

System capacity will be 6 tbps, and minimum performance level 100 gigabits up and down. The company's business plan is to locate ground nodes where undersea cables and fiber-optic networks come together and offer telecom carriers a way to extend their long-haul networks at lower cost.

The hybrid fiber/laser nature of Laser Light's network is key to circumventing weather. As the footprint of each MEO satellite covers a continent-size area, there will be multiple ground nodes in sight at all times, all connected to a terrestrial fiber-optic network.

"Say we have to deliver service from Hong Kong to Marseilles," says CEO Robert Brumley. "If Marseilles is impacted by weather, then the system automatically acquires the ground node in Milan and drops the data there, where it goes by the lowest-cost, lowest-latency terrestrial route to Marseilles." This will be done automatically using algorithms for which patents are pending, he adds.

"We will have transport agreements with other carriers—and something to offer them to offset when they are off-net," he says.

To demonstrate the capability on the ground, Laser Light plans to build the High Articulation Laser Optics (HALO) Center with a 100-gbps hybrid fiber-laser-fiber loop to validate free-space optics performance and interoperability with terrestrial fiber-optic networks.

Laser Light is using free space optics technology developed for the U.S. Air Force's canceled Transformational Satellite Communications (TSAT) program, and in 2014 selected one of the companies involved in TSAT, Ball Aerospace, to supply its laser-comm payload and off-the-shelf satellite bus.

The ground-segment provider will be announced shortly, says Brumley. Both suppliers have signed fixed-price contracts. The first customer to sign up is regional carrier Hong Kong-based Pacnet Services Asia Pacific.

Brumley says the system will use the same 196.5-THz frequency and 1525-1550-nanometer wavelengths as terrestrial fiber optic. "In terrestrial communications, the further you push data on the transport layer the more expensive it gets," he says. "It's an operating expenses challenge. With our system, the further you go the cheaper it gets because of the operating efficiency of the satellite."

U.S. AIR FORCE

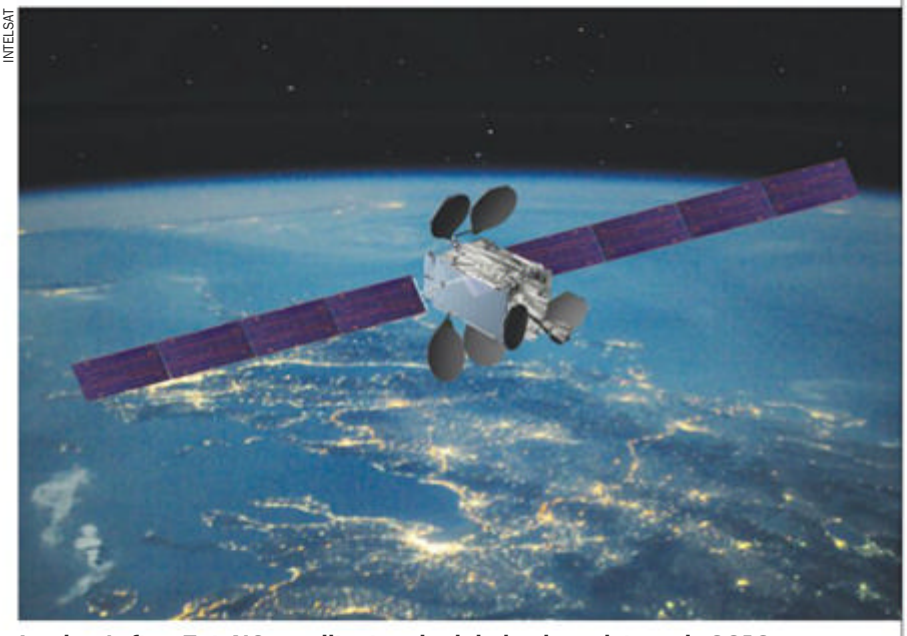
Tesat Spacecom and General Atomics will demonstrate laser links between an MQ-9 Reaper and Inmarsat's Alphasat in GEO.

Landgrab in Space

As Silicon Valley moves into the satellite sector, established players see competition, opportunity

Amy Svitak Paris

Major satellite operators are being asked to defend their business plans against the possible arrival of hundreds and potentially thousands of low-Earth-orbiting Internet satellites over the next decade, although most say they are not worried about the likes of Facebook, Google and OneWeb eating into their profit margins.



INTELSAT

Intelsat's first EpicNG satellite is scheduled to launch in early 2016.

Instead, established satellite service players have largely welcomed Silicon Valley's sudden interest in the space sector—including some fleet operators who see the potential to collaborate with new low-Earth-orbiting networks.

At the same time, however, these operators are designing satellites that in some broadband markets—notably aviation and maritime—will provide many of the same services the proposed low-Earth orbiting constellations are targeting (see page 59). Several fleet operators are already making headway in offering global, high-throughput broadband, particularly aeronautical, a sector that exploded last year with a gamut of connectivity offerings in L-, K_a-, K_u-, and even S-band frequencies.

"It's going to be competitive, obviously, because it is a very attractive marketplace," says Rupert Pearce, chief executive of London-based mobile satellite services provider Inmarsat, which is in the midst of deploying a geostationary constellation of all-K_a-band Global Xpress satellites that will deliver seamless, high-throughput broadband globally to civil and government customers for aircraft and ship connectivity. "There's a lot of opportunity, and aviation connectivity isn't the only area. [The fast-growing markets] are attracting serious players."

In the last five months, the International Telecommunication Union has registered at least six LEO communications satellite constellations, several of which resemble those proposed in January by SpaceX and OneWeb, companies backed by Silicon Valley financing from Google and chip-maker Qualcomm, respectively. Since then, a company dubbed LeoSat recently hired Vern Fotheringham, the founder and former CEO of flat-panel antenna builder Kymeta Corp., and is planning its own constellation of more than 100 satellites in LEO for Internet trunking.

These proposals have prompted comparisons with Teledesic and SkyBridge, two well-financed ventures in the late 1990s whose visions of delivering high-speed broadband to the masses were thwarted by technical setbacks.

Parallels have also been drawn with more contemporary ventures, notably O3b Networks based in Britain's Channel Islands. Co-founded by OneWeb's Greg Wyler, O3b operates a constellation of 12 K_a-band broadband satellites in an unusual medium Earth orbit, delivering Internet trunking and mobile backhaul to large telecom companies, and high-speed broadband to the maritime and energy sectors.

Backed by fixed satellite services operator SES of Luxembourg, O3b is an example of the collaborative opportunities new satellite Internet constellations present to existing players, even as most agree the entry into service of new LEO networks is unlikely in the current decade.

"Certainly we think there's a place for GEO in these new applications, because only a few require lower latency, and maybe GEO combined with LEO would be attractive for certain applications," says Stephen Spengler, incoming CEO of Intelsat, a provider of mostly fixed satellite services to government and commercial customers that is developing the new Epic high-throughput family of satellites in K_u-, C- and eventually K_a-band set to begin launching early next year. But Spengler says he is skeptical that Google and OneWeb can offer operational services anytime soon. "I'm sure they're going to continue to work through the bugs, but it's going to take a long, long time to do it."

Michel de Rosen, CEO of Paris-based Eutelsat, agrees, asserting constellations of hundreds or thousands of LEO satellites are years off as they grapple with feasibility and cost challenges. In a Feb. 12 conference call with investors he cited a litany of obstacles such constellations must surmount: "Complexity and cost of ground antennas, both for tracking and handover on the end-user side; the cost of the ground segment; the go-to-market approach, particularly in emerging markets; regulatory uncertainty regarding spectrum and country licensing; and unknowns such as increased risk of space pollution," he told investors. "In that context, we believe market entry

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is not likely before end of decade in the most favorable scenarios."

Wyler, however, says his start-up venture intends to begin launching prototype spacecraft beginning in early 2017, with the full constellation to be operational in early 2019.

"There will be a lot of benefits we can provide from the system prior to the full constellation being active," says Wyler, whose company is backed by Virgin Group and chipmaker Qualcomm, both of which will contribute technological know-how to the effort.

In an interview Wyler acknowledged the challenges to satellite internet constellations, notably the issue of spacecraft "handover" to tracking antennas on the ground or aboard vehicles, including aircraft and ships. But he touted the fundamental benefits of LEO constellations, notably the fact that his spacecraft will operate 36 times closer to Earth than a satellite in geosynchronous orbit (GEO).

"The result of that is one, our latency is lower, so the performance of the web is much better and snappier," he says. "Second, because it's closer, the antennas can be smaller."

In addition, a variety of antenna technologies are available for what Wyler says is, in effect, a stronger signal due to this short distance.

"It doesn't mean higher power from the satellite but just that it is closer, so the antenna sizes can change dramatically," he says. "We're designing internally a number of different antennas and looking at options for different types of vehicles in a range of uses."

Although OneWeb is targeting emerging markets in remote parts of the globe, Wyler says his company plans to introduce aeronautical broadband service, and is exploring opportunities with terminal and antenna supplier Honeywell Aerospace to equip the full range of aircraft—from private airplanes to jumbo airliners and combat jets.

"Because the satellites are closer, and the antennas can be smaller, it opens up the connectivity for lots of different types of aircraft," says Carl Esposito, vice president of marketing and product management at Honeywell. "We think the antenna technology will enable us to equip three to five times more types of aircraft than we can with today's systems."

Eutelsat's de Rosen, whose company offers 90 gbps of high-throughput capacity with its KA-SAT K_a-band broadband satellite, says he will pay special attention to the evolution of OneWeb and other LEO constellations, and does not exclude the potential to become involved in the segment in the long term.

"But our focus is KA-SAT and high-throughput payloads on conventional satellites," de Rosen said in February. "We have proven technologies already available and where demand is significant: The high-throughput payload on Eutelsat 65WA, pre-sold two years ahead of launch to Echostar, for example."

U.S. satellite operator ViaSat Inc. also expects to play a role in emerging satellite Internet constellations. In 2011 the long-time ground-terminal supplier launched its own spacecraft, ViaSat-1, to supply high-speed consumer K_a-band broadband in the U.S. and multi-megabit-per-second links for aeronautical connectivity. With the launch next year of a second and even larger spacecraft, ViaSat-2, the company will team with Eutelsat to stretch coverage between North America and Europe using KA-SAT.

"Bigger satellites that have more payload are going to be more efficient than satellites with little payload."

ViaSat CEO Mark Dankberg says so far, the company's Exede in the Air aeronautical broadband offering has had good take-up with both United Airlines and JetBlue. As such, Dankberg says he questions the benefit of Internet constellations in LEO, given the capacity of much larger broadband payloads in GEO or planned to launch in the next few years.

"We've invested a bunch in the GEO stuff, and have really good metrics for what we can achieve," he said in February. "We'll be bringing that to market in a time frame that is probably sooner than the LEO systems will."

That said, ViaSat has had a hand in every LEO and MEO ground segment in existence today, and is likely to team with companies seeking to deploy new satellite Internet constellations in LEO.

We're pretty vertically integrated and feel we have good technology there," he said, adding that ViaSat might be interested in partnering in other areas as well.

Still, he said, multiple challenges to LEO constellations persist.

"Basically you are going to end up with highly integrated satellite payloads which are a lot more integrated than what you see in current-generation technology," he said. "If you just look at efficiency measures, bigger satellites that have more payload are going to be more efficient than satellites with little payload."

Dankberg said there is also the concern that manufacturing large numbers of satellites is a byproduct of the limitations of the ground segment.

"If I want to have a reasonable ground terminal, I need hundreds or thousands [of spacecraft] in order to have reasonable look-angles to the satellite," he said. "Then there is also the issue of geographic distribution of the bandwidth. Those are sort of hard economic problems independent of whether the technology works."

David McGlade, Intelsat's outgoing chief executive, says in addition to technical challenges, much remains to be clarified as to the business models for satellite Internet. He notes that the motivation for new entrants, particularly Google and Facebook, appears rooted more in philanthropy than profit, at least in the near-term.

"The real point is to access the two-billion-plus people in the world who have limited or no connectivity, and it allows these providers to hopefully do good things for the world and maybe make some money along the way," McGlade says, asserting Intelsat has been delivering services to the developing world for years. Still, he said, "we needed better technology, with more cost-effective platforms, and that will be part of the evolution of Epic as we continue to develop market share and go after new applications."

Wyler says his reason for building the constellation is aimed at emerging markets and connecting the digital have-nots. "The initiative is to enable affordable access for everyone and really take the question of connectivity and availability off the table, so everyone has the option," he said. "We hope in the next few years to step beyond 'is it available?' and to step into 'what do you do with it?'"

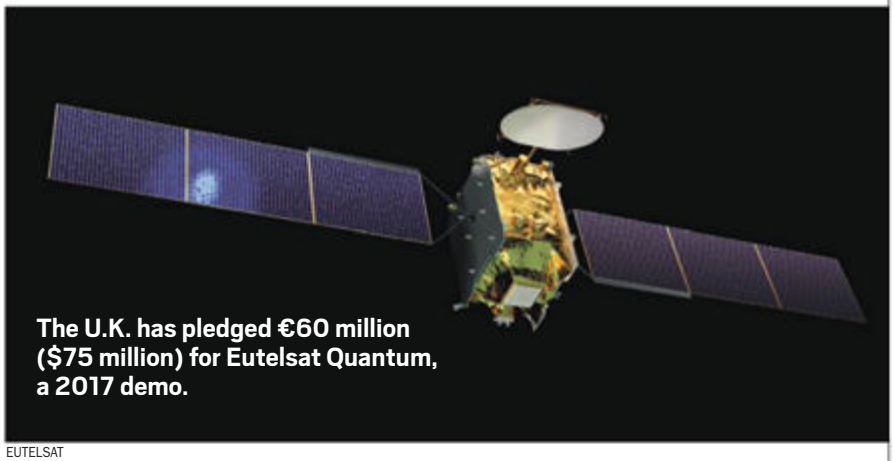
Increasing Flexibility

Fleet operators backing new generation of software-defined spacecraft

Amy Svitak Paris

Communications satellites are living longer in orbit, a technological advance that is a mixed blessing for fleet operators, given that payload processors flying aboard such spacecraft can become outmoded in as little as five years. Today, communications satellites are equipped with antennas designed for a specific frequency plan and coverage area over certain regions, an approach that can leave fleet operators tethered to a single business case during the spacecraft's 15-20 years in orbit.

With the advent of software-defined payloads, however, such satellites could be directed to various orbital slots from the ground, while their power and bandwidth are reconfigured in orbit.



The U.K. has pledged €60 million ($75 million) for Eutelsat Quantum, a 2017 demo.

EUTELSAT

Paris-based Eutelsat is taking a step toward such a capability with the new Eutelsat Quantum class of satellites being developed with co-financing from the U.K. government.

Led by prime contractor Airbus Defense and Space, which is providing the payload, and Surrey Satellite Technology Ltd. of Guilford, U.K., which is supplying the small geostationary satellite platform, the K_u-band Eutelsat Quantum will allow coverage areas to be redefined via software uploads in response to shifting service demand.

"When you don't know tomorrow what region to serve and how much bandwidth you need and how much performance for the terminal on the ground, Eutelsat Quantum is the only way you can really match that very efficiently," says Jacques Dutronc, the company's chief development and innovation officer.

Slated to launch in 2018, Eutelsat Quantum will feature a phased-array antenna that will enable controllers to direct beams independently through ground commands, marking a step in the direction of truly software-defined payloads that Dutronc and other fleet chief technology officers say are not far off on the horizon.

In addition, Dutronc says because portions of Eutelsat Quantum's K_u-band frequency can be paired, the satellite class will easily overcome regulatory barriers in different regions governed by the International Telecommunication Union (ITU), which assigns radio frequency spectrum to fleet operators.

"Depending on the ITU filings under which you're operating, you can adapt to the market change, you can use beam hopping for all kinds of applications and be extremely versatile to a level that the satellite industry has never been able to offer," he said.

Fleet operator Intelsat is also shifting to more flexible payload capabilities with its new line of EpicNG high-throughput satellites.

"We are introducing more and more flexibility to reconfigure a spacecraft in orbit," says Intelsat Chief Technical Officer Thierry Guillemin of the new Boeing-built Epic line of spacecraft. "Once in orbit, you want to define the satellite's connectivity from the ground, where you want the power to be in the coverage, and how you want the coverage to be shaped."

With six EpicNG satellites under contract, Guillemin says the platform will evolve in stages, starting in K_u-band with Intelsat 29e. Slated to launch in early 2016, it will offer full connectivity between spot beams.

"No other satellite has this kind of connectivity in the world," he said. "It's what gives us the backwards compatibility of Epic and makes it possible to integrate it completely with the rest of our fleet."

Subsequent EpicNG satellites will introduce the ability to move power around within coverage areas based on changing demand, and ultimately to shape coverage from the ground.

In the future, he says fully software-defined satellites also hold the promise of changing procurement models.

"If I have the ability to define spacecraft completely in orbit, it means the manufacturers are able to build the same model of spacecraft over and over, and then the operator will configure it after its launched," he said. "That means the manufacturer does not need to wait for my order for building the spacecraft."

Martin Halliwell, chief technology officer at Luxembourg-based SES, says he envisions a fully software-defined payload that would allow spot-beam reuse and reallocation on both a geographical and service-level basis.

"Say you have a high-throughput-like laydown of beams and you have an aircraft with a mobility data package flying through the beams; once it's left a beam, what do you do with that beam?" Halliwell asks. "What I would like to do is be able to take that resource—the beam, the coverage, the power, the activity in there—and put it back into a pool to be reassigned."

Halliwell says this approach could enable multiple layers of service-level agreements with mobile broadband service providers, who could make bandwidth connectivity available either on a demand or primary-allocation basis.

"So it would be a flexible payload, and the next stage from that is almost a cognitive payload that decides where best to use the bandwidth," he says.

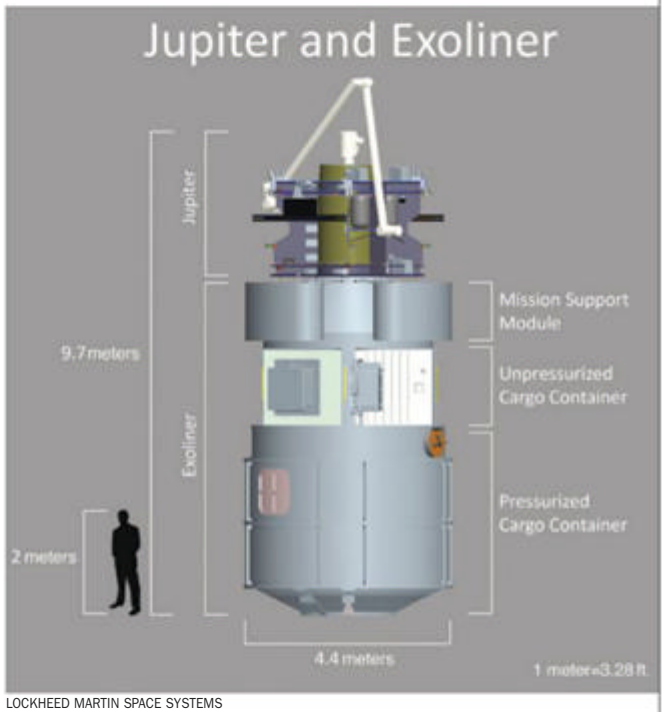
‘Extensible’

Lockheed, MDA, Thales Alenia team on ISS and deep-space cargo carrier

Frank Morring, Jr. Washington

An international team headed by Lockheed Martin hopes to parlay a modular “general-purpose space utility vehicle” it has proposed for NASA’s second-round commercial-cargo competition into a human-spaceflight services business ranging from low Earth orbit (LEO) to Mars.

Dubbed “Jupiter” for one of the locomotives that met in the Utah desert to complete the U.S. transcontinental railroad, the proposed vehicle would marry the spacecraft bus Lockheed



LOCKHEED MARTIN SPACE SYSTEMS

Martin Space Systems Company builds for its interplanetary probes with a robotic arm supplied by Canada’s MacDonald Dettwiler Associates (MDA) and a pressurized module built in Italy by Thales Alenia Space.

For cargo deliveries to the International Space Station under NASA’s second Commercial Resupply Services (CRS-2) work package, the Jupiter spacecraft bus and robotic arm would remain in orbit indefinitely after launching on an Atlas V with the first in a series of cargo modules attached. Identical cargo modules filled with pressurized and unpressurized supplies and station gear would arrive periodically after that on Atlas Vs, using the launchers’ Centaur upper stages to rendezvous with the Jupiter bus.

The Jupiter’s Canadian robot arm would grapple the arriving cargo module and attach it to the Lockheed Martin bus, which would move it into position to be grappled and berthed by the station crew. Astronauts would use the station’s larger robotic arm for the job, just as they receive cargo deliveries from the Orbital ATK Cygnus and SpaceX Dragon commercial cargo carriers flying under CRS-1 today.

The Italian-built module would remain berthed at ISS for the crew to unload and refill with trash. It would be discarded for destructive reentry after several months, and replaced with a fresh load of cargo arriving in a new module delivered by the Jupiter. But under Lockheed Martin’s ambitious plan, that would just be the beginning.

“What we’re envisioning here is something that we think has commercial application well beyond ISS,” says James Crocker, vice president and general manager for the space systems company’s new international unit. “In fact, on these missions themselves, one of the things we have put in our proposal is how we will reduce the cost to NASA and share the profits with NASA for commercial use of this.”

Just as NASA and its space-exploration partners envision a stepwise route to land human “pioneers” on Mars, the Jupiter partners see themselves providing commercial cargo and other services—including human habitats—at each step along the way. Crocker compares the idea’s commercial potential to the railroad cars that sent U.S. foodstuffs to East Coast ports for shipment to Europe in the 19th Century.

Jupiter was the name of the first eastbound Central Pacific Railroad locomotive to travel the completed transcontinental rail line. The spaceborne Jupiter vehicle could play the same role for the inner Solar System, says Crocker.

“Exoliner” vehicles would rendezvous with the Jupiter bus, using the Atlas launcher’s Centaur upper stage for accurate positioning.

“Picture a future of interplanetary shipping lanes to the Moon and to Mars, with autonomous vehicles carrying supplies and scientific instruments and construction materials for habitats, robots in orbit for fueling, repairing, respositioning satellites,” he says. “Picture commercial hosted payloads, cubesats by the hundreds that would share space on this vehicle with perhaps NASA Earth-observing instruments, turning a profit and reducing the cost of supplying the station in orbit, but more importantly laying the foundation for a true commercial business in space.”

To that end, Lockheed Martin has made a “very substantial” but unspecified investment in the project, Crocker says. A win in the CRS-2 competition will hasten the development, including the addition of solar-electric propulsion for missions beyond LEO, but the team plans to continue the work with or without the ISS cargo contract, he says.

At least four other companies have entered the CRS-2 competition, which calls for delivery of 15,000 kg (33,000 lb.) of pressurized cargo and 2,000 kg of unpressurized “upmass” from the expiration of the initial CRS contracts after 2016. Incumbents Orbital ATK and SpaceX are in the running. Sierra Nevada plans to enter a variant of the Dream Chaser lifting body it unsuccessfully proposed for NASA’s commercial crew program, and Boeing has entered a cargo version of the CST-100 capsule that was a winner in the commercial crew competition. Blue Origin, which also is developing an orbital vehicle that may be suitable, won’t say if it bid on CRS-2.

Lockheed Martin and its partners have cobbled together the Jupiter “exoliner” from a lot of flight-proven hardware. NASA is flying the basic spacecraft bus at Mars on the Mars Reconnaissance Orbiter and Mars Atmosphere and Volatile Evolution probes, on the Juno spacecraft approaching Jupiter, and on the Origins Spectral Interpretation Resource Identification Security Regolith Explorer asteroid sample-return mission set for launch in September 2016.

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Lockheed plans to keep the bus and arm operating indefinitely by launching more of its hypergolic fuel in spherical tanks housed in a ring-shape structure at the end of the cargo module that berths with the bus (see illustration, page 60). The unit also can carry fluids to the ISS.

Between the fluid ring and the pressurized module is an open space comparable to the "trunk" on the SpaceX Dragon, where unpressurized cargo destined for the station's exterior can be carried. Crocker says Lockheed Martin has developed a 9U cubesat dispenser for the open space to accommodate secondary payloads at the smallest end of the size scale, although much larger birds can be accommodated for ridesharing.

"On the first mission, of course, we carry the Jupiter module up," he says. "This whole stack is rated to carry the Jupiter module, so we could actually launch satellites as large as Jupiter on future missions. Now we'd have to add a strap-on [booster] to the Atlas to do that, but that's millions of dollars—it's not tens of millions of dollars—so we can launch satellites as large as Jupiter and as small as a cubesat."

Adding solid-fuel strap-ons also adds altitude to the orbits Jupiter can reach, although the CRS-2 concept is optimized "with a lot of margin" for the low ISS orbit to save money. For missions to geostationary orbit and beyond, the company has a concept it calls "Jupiter Electric" that uses solar-electric Hall thrusters designed as an upgrade for the Lockheed Martin A2100 commercial satellite bus.

"The only addition to this is the A2100 Hall-current thruster packs that we put on," Crocker says. "It would actually be more packs than are on our A2100, but those are being designed, built and flight qualified right now."

To power the spacecraft and its electrical systems, including the Hall thrusters, plans call for two or four fold-out solar arrays based on the lightweight Lockheed Martin arrays in use on the ISS since its P6 truss element was installed in December 2000. That sort of heritage is clearly a selling point for the CRS-2 proposal.

Starting Over?

Engine adjustments could turn back the clock on Falcon 9 recertification

Amy Svitak Paris

An optimized Merlin 1D engine and other enhancements to the Falcon 9 v1.1 will give Space Exploration Technologies (SpaceX) the ability to lift commercial communications satellites to orbit while continuing to develop the rocket's reusable core stage. Elon Musk, founder and chief executive of Hawthorne, California-based SpaceX, says the improvements include a 15% boost in thrust for the rocket's nine core-stage engines, as well as super-chilled propellant and a 10% increase in the volume of the upper-stage tank, according to Musk's Twitter feed.

Such performance improvements would allow the company to continue innovating while drawing revenue from a growing backlog of commercial missions.

However, if the design changes are significant, they could prevent SpaceX from lifting sensitive civil and military payloads on the retooled Falcon 9 without subjecting it to further scrutiny beyond U.S. Air Force and NASA launch-vehicle certification efforts already underway.

While the agencies maintain separate protocols for certifying new launcher entrants for government missions, they share findings and assessments during the process. Certification is meant to ensure commercial service providers can adhere to standards and processes established over decades and honed in the 1990s after a series of costly launch failures.

Both agencies expect to complete Falcon 9 certification mid-year, though NASA says once the vehicle is approved to lift higher-value science payloads, in the future it does not plan to fly them on SpaceX launchers with refurbished Falcon 9 cores.

"Our current Category 2 certification effort assumes the use of an un-refurbished core stage," says NASA spokesman Joshua Buck, referring to the ongoing effort to certify the Falcon 9 to launch Earth-observation spacecraft, starting with the Jason-3 ocean altimetry mission set to lift off in June from Vandenberg AFB, California.

For now, NASA says it is unaware of any proposed changes to the current Falcon 9 vehicle and that Jason-3 is not the inaugural customer for an upgraded rocket; that will be SES-9, a communications satellite built for commercial fleet operator SES, an early backer of SpaceX. Although the conservative Luxembourg-based company showed initial reluctance to fly on the inaugural Falcon 9 mission, CEO Karim Michel Sabbagh has since said the launch will go forward, ideally in the second quarter of 2015, if not the third.

A year ago Musk told Aviation Week he planned no major improvements to the Falcon 9, though he said SpaceX would be "chilling the propellant to densify it, to get more propellant load for the given volume." The change would enable the rocket to carry more fuel, even with heavier payloads, enabling the core stage to return to Earth for a controlled landing on a SpaceX drone-barge in the Atlantic off the coast of Florida.

The downside of such changes, however, is that they could require additional government work to certify an upgraded Falcon 9, if SpaceX seeks it.

NASA says SpaceX has been working to achieve so-called Cat. 2 "medium-risk" certification for Falcon 9 since the $82 million Jason-3 launch contract was awarded in July 2012. However, in January 2011, James Norman, head of NASA's Launch Services Program (LSP) office, said the agency's Falcon 9 certification effort was underway at the time: "LSP is working to get it certified, and I think we're looking at spring 2013 to have it on board" for Cat. 2, mainly for Earth science missions, Norman told the NASA Advisory Council's planetary science subcommittee. "Eventually, it will be a Cat. 3 launch service that will be available for planetary as well."

Since June 2010, when SpaceX debuted a baseline version of Falcon 9—the v1.0—the rocket has already undergone one major transformation: In fall 2013, the current and more powerful v1.1 was introduced, complete with stretched tanks and a new Merlin 1D engine, replacing the baseline rocket's Merlin 1C.

As a result, SpaceX and NASA have had to redo much of the early work in certifying the baseline vehicle.

"Much of the work related to design and components had to be re-accomplished by SpaceX with the switch from the Falcon 9 v1.0 to the Falcon 9 v1.1 vehicle," says NASA spokeswoman Stephanie Schierholz.

"This is real space," says Crocker. "It's a real interplanetary spacecraft; it's a real ATV; it's a real robotic arm; it's a real refueling system, and the electrical portion of this is basically our commercial A2100 Hall-current thruster system, with the arrays that you see. If you're trading weight and power, there's a reason the station arrays are like that."

With the modular approach, the heritage hardware used on Jupiter would be "extensible" to Mars, says Crocker, using a buzzword popular in human-exploration circles (*AW&ST* June 23, 2014, p. 44). The team is working on rigging the pressurized-cargo section as a habitat. Crews could use it at a human-tended deep-space outpost in one of the stable orbits near the Moon—distant retrograde orbit or the Earth-Moon L2 Lagrangian point—that NASA is eyeing as a "proving ground" for Mars-exploration vehicles, and Crocker says the Jupiter hardware also could serve a resupply function there or for bases on the lunar surface. "If we didn't see a market for this beyond the space station, we wouldn't be investing the kind of dollars we're investing in it," he says.

Crocker says the idea has gone over well with "venture capitalists and commercial operators who really are looking for low-cost access for satellites to space," as well as within his own company and with its international partners.

"We've had discussions about what other countries have a very strong interest in lunar return, going back to the Moon," says Crocker, an experienced space-exploration engineer responsible for standing up Lockheed Martin's new international space unit. "We've had a lot of discussions with our industry partners and other folks who are interested."

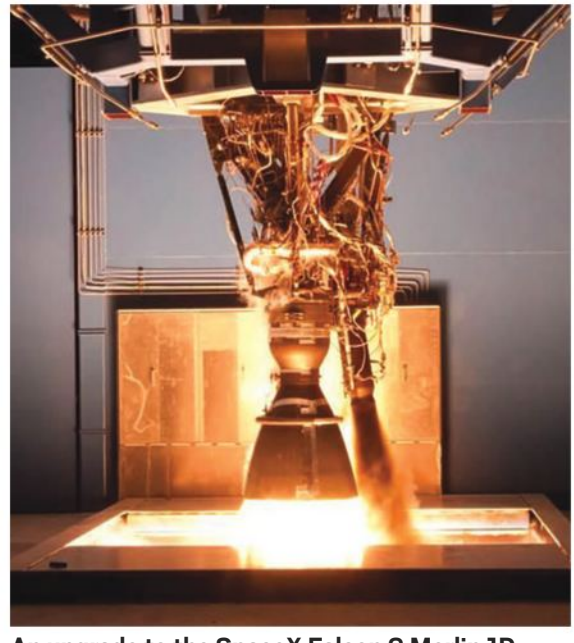
The space station is the key for now—a place to refine the systems needed for the push deeper into the Solar System that the Jupiter partnership hopes to commercialize.

"It would be very difficult to afford to do this if it weren't based on the CRS as the foundation," Crocker says. "So I would say that while I think that ultimately this vehicle will get built, without CRS-2 as a foundation, it would be pushed way out."

"Also, the certification element related to the number of successful flights and the related detailed flight-data review had to be started anew," Schierholz said, though much of the "process-related work," including quality, manufacturing, operations and systems engineering, was able to continue.

Although NASA's certification strategy for the Falcon 9 v1.1 required three flights, the fact that SpaceX never vacuum-tested the upper stage on the ground prompted the agency to add two additional missions to achieve certification.

"NASA required SpaceX to add additional instrumentation and complete five consecutive successful flights of the Falcon 9 v1.1, rather than the three that are required [for Cat. 2 certification], in order to provide upper-stage engine performance data while operating in a vacuum," Schierholz said, adding that those missions have all been successfully flown.



SPACEX

An upgrade to the SpaceX Falcon 9 Merlin 1D engine aims to increase thrust by 15%.

In May 2014, the Air Force said it was spending $60 million on its Falcon 9 certification effort, which began in 2013.

Although LSP would not disclose how much NASA has spent to date on certifying the Falcon 9, the agency did invest approximately $1 million in the development of additional instrumentation installed on the five SpaceX flights to generate data on the upper-stage engine performance in a vacuum, says NASA's Buck, adding that LSP—which has an annual budget of around $87 million—did not augment its workforce as a result.

NASA says if the Falcon 9 is upgraded in the future, it will review the performance and design changes and decide whether those changes will require a new certification.

"A thrust increase alone would not immediately result in a new common launch vehicle configuration," Buck says. "However, often such changes are accomplished by major design differences throughout the engine and include propellant tank changes that affect the burn time and vehicle mass significantly," he says, adding that NASA considers the effect on loads, controls and aerodynamics in making a determination. If the agency finds modifications that constitute a new launch vehicle configuration, then a certification strategy that complies with NASA regulations would be put in place and "such a strategy would define the number of flights required to achieve NASA certification," Buck notes.

LSP isn't sure how many additional flights of an upgraded Falcon 9 may be needed, if any.

"It will depend on what changes, their magnitude, and when the contractor would desire to cut them in," Buck says, adding that the agency does not currently plan to certify the vehicle for higher-risk Cat. 3 missions, which would include planetary and astronomy missions.

He says the major differences between a "Cat. 2" and "Cat. 3" certification are the number of consecutive successful flights required and that NASA can choose to accept more risk for a Cat. 2 certification versus a Cat. 3.

NASA has already gone through the process of fleet-certifying the United Launch Alliance Atlas 5.4-meter (18 ft.) and 5-meter fairing launch vehicles and was the first government customer to fly on both Atlas 5 variants. The agency says it is not unusual to evaluate proposed launch vehicle changes and decide whether a new certification is necessary. And while significant changes to core propulsion systems are less common, NASA says it is in the process of certifying the Atlas V with the RL-10C-1 on the Centaur upper stage.

"Our certification activity will be completed before NASA's first use of this configuration next year," Buck says.

Nuanced Numbers

Overall incursions continue to rise, but risk to airline passengers appears under control

John Croft Washington

Runway incursions for all types of aircraft in the U.S. continue to increase at an alarming rate despite a consistent decline in the number of operations at towered airport; the trend is much less pronounced for fare-paying passengers flying on airliners or air taxi aircraft. In both sectors, however, the number and rate for the most severe incursions appear to be in check and are well below the FAA's safety goal.

An Aviation Week analysis of the FAA's Aviation Safety Information Analysis and Sharing system in the calendar years 2010-14 shows a linear increase in total incursions for all aircraft at more than 500 towered airports in the U.S., with an approximate growth of 37% over the period to 1,270 incursions at the end of 2014. The rate of incursions increased roughly 37% as well, to 25.6 incursions per 1 million operations, where an operation is defined as one takeoff or landing.

For airliners and air taxi operations, however, incursions grew by only 3% over the period, to 284 at the end of 2014. Assuming a linear fit to the data, the rate of incursions appears to be rising at a 7% clip, finishing 2014 at 13.2 incursions per 1 million operations. Mathematically speaking, that means the chances of having an incursion of any type in an airliner or charter are approximately one in every 38,000 flights (assuming one flight comprises two operations and not counting international flights). The risk in flying aboard any

Runway Incursions at Top 10 Busiest U.S. Airports, 2014

Atlanta (ATL)
Los Angeles (LAX)
Chicago (ORD)
Dallas (DFW)
Denver (DEN)
New York (JFK)
San Francisco (SFO)
Charlotte (CLT)
Las Vegas (LAS)
Phoenix (PHX)

Source: FAA/Aviation Week

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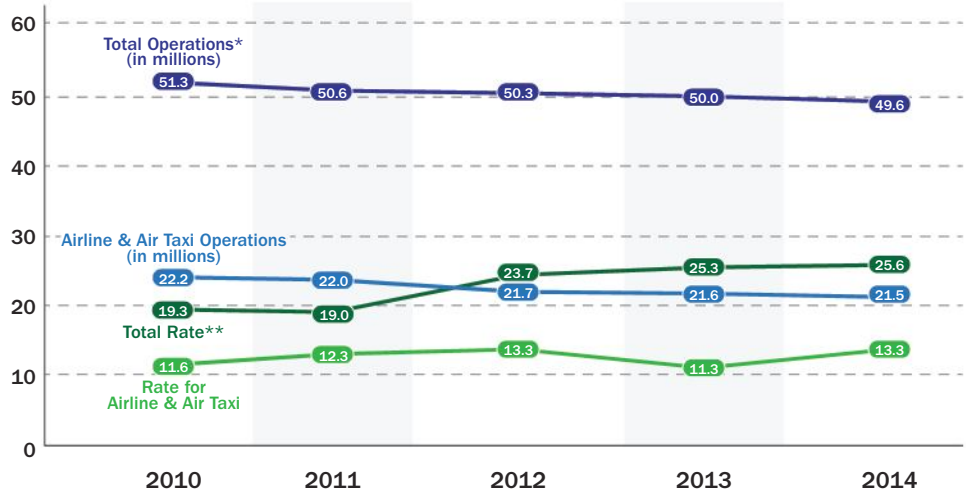
The mix of complex airport geometries and large aircraft brings the issue of runway safety into focus as airports perfect customized intervention strategies. A380s featured prominently in two runway incursions in 2014.

Total***	Rate**
16	18.6
25	40.6
18	20.6
15	22.3
7	12.3
15	35.5
12	28.8
23	44.4
9	19.2
4	9.8

**Per 1 million operations

***Airline and Air Taxi

Runway Operations and Incursion Rates at U.S. Airports



*Operations are takeoffs and landings
**Rate is incursions per 1 million operations

Source: Total operations from FAA Air Traffic Activity Data System

aircraft in the U.S., including general aviation and military, is roughly one incursion every 19,000 flights.

In terms of who caused an incursion—pilots, controllers, or pedestrians or vehicles on the runway—airline and air taxi pilots appear to be doing the best job of improving. In 2010, 57% of incursions were attributed to "pilot deviations," compared to 33% for operational incidents (controller errors) and 10% for vehicle drivers or pedestrians. By the end of 2014, pilot deviations had linearly decreased to 39% while operational incidents linearly increased to 48%; vehicle and pedestrian incidents remained relatively constant. One reason that could account for the rise in controller incidents is that controllers may be more comfortable reporting events thanks to non-punitive provisions in the FAA's Air Traffic Safety Action Program. The downward trend for airline and air taxi pilot faults is contrary to that of the overall piloting community, which is seeing an increase in errors, largely attributable to general aviation pilots in light aircraft.

Regardless of the cause of the error, the good news is that in the past five years the FAA has continued to record a very low number of Category A and B incursions, whereas most of the growth has been in Cat. C incursions. Cat. A and B incursions are those in which a collision was narrowly avoided or evasive actions were needed, respectively; in Cat. C and D incursions, the pilot, driver or pedestrian had "ample time" and/or distance to avoid a collision or there were no immediate safety consequences, respectively, according to the FAA.

In 2014, a total of 12 Cat. A and B incursions were reported, representing a rate of 0.24 incursions per 1 million operations, which is below the FAA's safety goal of 0.36 per million operations (about 20 incursions per year). The airline and air taxi sector reported four Cat. A and B incursions in 2014, a number that has been relatively constant since 2010, and translates to approximately one incursion for every 3 million flights.

The superior record for Part 121 and Part 135 operations is likely linked to increased focus on the problem within airline and charter operations, as well as focused efforts by individual air carrier airports and the FAA to address problems using a mix of procedural, technological and human factors, and taking into account specific geometric constraints of runways. The increase could also be attributed in part to the rise in safety management systems, which have provisions for non-punitive reporting by pilots and controllers in return for giving the FAA the information it needs to target problem areas.

The FAA credits its "event-based multidisciplined approach" for a drastic improvement from the 67 Cat. A and B incursions in 2000 (one serious incursion per 1 million operations), although it is likely that a 27% decrease in operations since then has also helped reduce the rate.

By contrast, the rate of less severe Cat. C and D incursions, in which the FAA decides there was "ample" room and time to avoid a collision, has increased 44% and 17%, respectively, since 2010, to 12 incursions per 1 million operations for Cat. C and 14 incursions per million operations for Cat. D. There are approximately 50 million operations per year at U.S. airports.

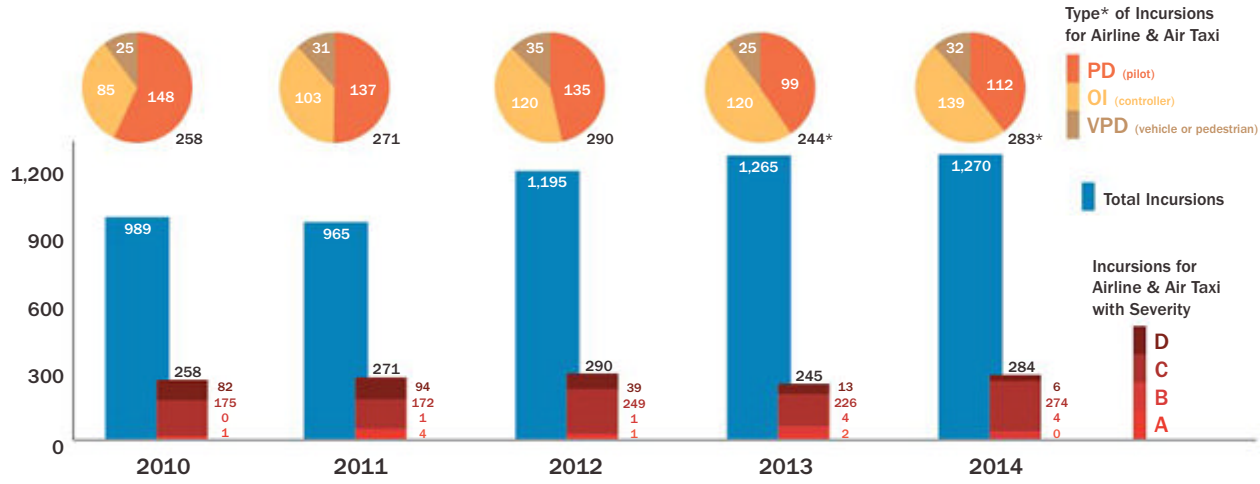
There is some skepticism within the industry that the FAA's in-house process of ranking incursions is not fully independent and therefore not repre-

DEJA TWO:

2014—Los Angeles Intl.—Cat C

Two pairs of A380s involved in Category C incursions in the same location five days apart. In both cases, one A380 that had just landed was incorrectly instructed to use a taxiway that did not provide the required separation from a second A380 taking off on the runway that parallels the taxiway.

Runway Incursions at U.S. Airports by Severity and Type



Note: "Airline and Air Taxi" includes Parts 121, 125, 129 and 135
"Total" includes Parts 91, 121, 125, 129 and 135, Military, N/A

*Type of Incursion: PD = pilot deviation, OI = operational error (controller), VPD = vehicle or pedestrian error. Total does not include one "other" type, so the sum is less than Category A-D totals. Ranked from A (most severe) to D (least severe)

Source: Incursion data from FAA Aviation Safety Information Analysis and Sharing database

sentative of the true threat level. The agency gathers the reports from its control towers; its Runway Incursion Assessment Team (RIAT), with representatives from Flight Standards, Office of Airports and the Air Traffic Organization, meets weekly to classify new events. Each of the three organizations gets one vote, and the FAA says "consensus is desired but not required" on the final vote. In the event of a tie, the manager of the Runway Safety Group has the final say, as well as for all Cat. A and B incursions.

According to the guidance for the RIAT, incursions involving only one aircraft, vehicle or pedestrian are automatically set at Cat. D; events in which would-be intruders stop more than 100 ft. from the edge of a runway should be classified as Cat. C, as are events in which the closest horizontal or vertical proximity is equal to or more than 2,000 ft. or 200 ft., respectively. However, if "any part" of an intruding vehicle or pedestrian is on the runway and the "closest unintended proximity is within 100 ft.," the incident should be ranked as Cat. A, says the FAA. The agency is currently testing a risk-based tool to help with the categorization.

Technology that was first deployed in 2002 is also proving beneficial. The FAA credits Airport Surface Detection Equipment Model X (ASDE-X)—a surveillance system that fuses ground radar, multilateration and Automatic Dependent Surveillance-Broadcast (ADS-B) and issues alerts for potential incursions—with providing controllers with the "improved situational awareness" that has led to a reduction in the number of Cat. A and B incursions. The agency says its ASDE-X program will be "deemed a success" if the number of Cat. A and B runway incursions "is maintained at the current levels or further reduced." ASDE-X is installed at the 35 largest airports in the U.S. and is also the foundation for related anti-incursion technologies including runway status lights embedded in the runway, or at runway crossings, that turn red when the runway is occupied, directly alerting pilots of a hazard.

The FAA's assertion is for the most part true based on the 2010-2014 incursion snapshot. Of the 35 airports, only 11 have experienced Cat. A or B incursions over the period, and only Chicago O'Hare International and Honolulu International experienced more than one. The worst year for O'Hare was 2011, when there were three Cat. A and one Cat. B incursions, all attributed to controller issues in the records and none of which discuss ASDE-X as providing the controllers with an early alert of an impending issue. None of the incidents resulted in an accident.

In Honolulu, however, the surveillance technology did save the day by alerting controllers that an airport vehicle was on the runway as a Boeing 767 was arriving. Controllers issued a go-around to the pilots, who passed overhead of the vehicle "at a low altitude," ranking the incident as a Cat. A. In a Cat. B incursion last year, ASDE-X also sounded an alarm to controllers, but the small aircraft continued on, landing on a closed runway, endangering workers.

Adding runway status lights to locations with ASDE-X will enhance the surveillance system by providing active alerts to pilots when a runway is occupied, speeding up preventative actions. Three prototype systems and a total of 17 operational systems are either installed or in the process of being embedded. But critics say the program is delayed, over budget and plagued by technical issues. They also note that it is being deployed at fewer airports than needed.

Data See 2010-14 runway incursion data comparing the top 10 busiest U.S. airports—tap here in the digital edition or go to **AviationWeek.com/RunwaySafety**

WINGLESS WONDER:

2014—Ryan Field (Tucson)—Cat D
ATC was advised by airport personnel of a person riding a bicycle on Runway 33. ATC observed the cyclist southbound on Runway 33. The cyclist was an employee of an airport tenant. An airport representative intercepted the individual and recorded his personal contact information. No conflicts.

DOG CATCHER:

2014—Chicago O'Hare—Cat D
Airport Operations notified the tower Runway 28C was closed due to a dog that escaped from cargo. While trying to catch the dog, a tug entered the taxiways and grass adjacent to Runway 28C. The tug did not enter the runway. No conflicts.

More Margin

The FAA's runway safety improvement effort is on schedule—and paying off

Sean Broderick Washington

While initiatives such as better flight tracking generate more headlines, the FAA has quietly made substantial progress on a long-standing, high-stakes effort to improve runway safety at hundreds of airports identified as posing the highest risk to aircraft overruns and undershoots.

The agency's plan, launched after the June 1999 excursion of an American Airlines MD-82 at Little Rock, Arkansas, targeted 642 commercial airport runway safety areas (RSA) as needing significant safety improvements. At the end of 2014, the FAA had earmarked $3 billion into projects to upgrade 603 of them, and the agency is on track to wrap up work or finalize plans at the remaining 39 this year, meeting a deadline imposed by lawmakers.

The work has ranged from constructing standard-size RSAs—which vary based on factors including a runway's length and types of aircraft using it, but are typically 1,000 ft. long and up to 500 ft. wide—to installing artificial beds that stop aircraft in spaces too short for them do to so unaided.

The case for improving RSAs is evident in safety data. The FAA and the National Transportation Safety Board say that, in the U.S., overruns account for "approximately 10 incidents or accidents every year with varying degrees of severity," while an FAA study found that 90% of overruns result in an aircraft coming to rest within 1,000 ft. of the runway end. Boeing data show that landing-phase accidents accounted for 18 fatal commercial airline accidents globally in 2004-14, more than any other flight phase. Those accidents killed 796 people, third-most behind loss-of-control and controlled-flight-into-terrain mishaps, and more than the next eight categories combined.

The FAA's work, which began with its first-ever RSA survey after the 11-fatality Little Rock accident, has made a difference. Among the RSA projects completed was one for San Francisco International Airport's Runway 28L, which Asiana Airlines Flight 214 was approaching when it landed short on July 6, 2013, ripping open the Boeing 777's rear fuselage and sending it sliding and twisting down the runway. The accident destroyed the aircraft and killed three of the 307 passengers and crew onboard, but the FAA believes it could have been much worse.

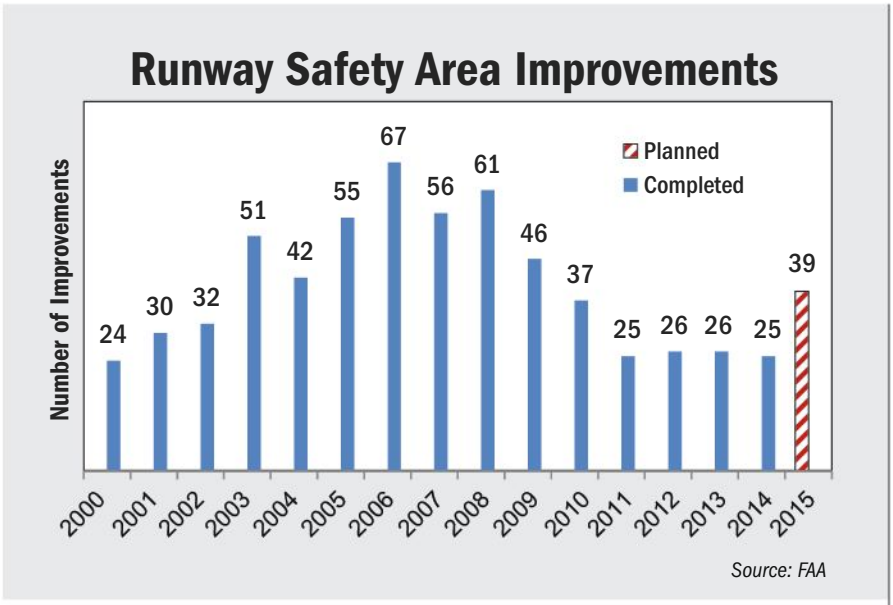
"Several hundred lives were saved because . . . the FAA's RSA Improvement Program specifically increased the RSA to account for undershoots to the standard distance by lengthening the distance between the end of the runway and the San Francisco Bay," the FAA notes in a report recently presented to the International Civil Aviation Organization. "Without this improvement, the aircraft likely would have crashed into the water."

The artificial beds, or engineered material arresting systems (EMAS), create effective RSAs where there is not 1,000 ft. of suitable extra space. EMAS are in place or slated to be installed in 98 RSAs at 62 U.S. airports. EMAS beds have stopped nine overrunning aircraft since 1999, including a Polar Air Cargo 747-200 freighter at New York John F. Kennedy International Airport in 2005 and a Mexicana Airlines Airbus A320 with 145 people onboard at Chicago O'Hare International in 2008.

The RSA improvement push helped Zodiac Aerospace's ESCO bring its EMAS product—which aligns crushable concrete blocks together to create a sand-pit-like effect that stops aircraft without damaging them—to market and thrive. In April 2012, the FAA approved a second vendor, Runway Safe, which builds its green EMAS-branded arrestor beds with a core of lightweight, insoluble silica foam made from powdered, recycled glass.

Runway Safe's initial installation is at

Runway Safe's arrestor bed cores are made by taking silica foam made from powdered, recycled glass and pouring it between geogrid walls that help keep the material in place.



The FAA plans to wrap up work on 39 runway safety areas this year, its most since 2009.

Chicago Midway International Airport, which opted to replace ESCO beds. The initial Runway Safe bed, a 245 X 170-ft. installation at the end of Runway 22L, went into place last November and is "weathering well through the harsh Chicago winter," says Kirk Marchand, head of Runway Safe's U.S. operations. Assuming the bed continues to meet expectations—instrumentation will soon be installed to help monitor the long-term effects of jet blast, among other things—Runway Safe could be awarded a sole-source contract to replace three more Midway beds and two at O'Hare by 2018.

ESCO's head start and the FAA's progress means the market for new EMAS installations in the U.S. is all but filled. But airport industry executives are encouraged by the competition, as U.S. beds still can be replaced and international opportunities abound.

"The presence of a second EMAS vendor is expected to create a competitive market for EMAS throughout the world, lowering costs and offering a variety of designs for airports," the FAA's RSA report notes.

ESCO's current offering, Emasmax, is a fourth-generation product that addresses some early shortcomings, such as providing a more effective cover material that helps keep moisture from damaging the blocks. However, its reliance on pre-cast blocks that must be installed or replaced on a block-by-block basis and are covered individually limits ESCO's ability to cut installation, repair and maintenance costs.

Runway Safe's design allows the bed to be poured and repaired with raw material trucked onsite and features a seamless, one-piece cover. The company says these measures minimize installation time as well as initial and recurring costs.

The FAA's RSA improvement plan is part of a multiphase effort to boost U.S. airport safety. The agency's next major initiative is improving taxiway geometry to help reduce runway incursion risks.

The 15-year project will be broken into three steps. First, the agency—using data compiled by experts at its William J. Hughes Technical Center in New Jersey—plans to identify taxiways with "problematic geometry" and prioritize them for inclusion in the project. The goal is to have the list completed during the first quarter.

The second step will be coordinating with the FAA's regional offices and setting up a plan to carry out the work. The final step—doing the work—is slated to begin in 2016.

An enlarged runway threshold built as part of the FAA's runway safety area improvement program likely kept Asiana Airlines Flight 214 from landing in San Francisco Bay.

NTSB

Boston Battles

Further improvement in runway incursions demands surgical approach

John Croft Washington

Runway and taxiway safety measures have evolved from the "silver bullet" mind-set of technology fixes to a mix of technological, procedural and analytical initiatives optimized at a particular airport for a particular runway.

At the tarmac level, boosting runway safety is a continuous hands-on process between the airport operator, airlines, FAA and other businesses in the movement area. At Boston's Logan International Airport, recent interventions include changes to the basic layout such as removal of some taxiways and building of new ones to reduce runway crossings, installing advanced ground surveillance systems and associated safety aids and developing new procedures for controllers.

XSIGHT SYSTEMS

XSight Technologies is expanding its automated foreign object debris system, installed in Boston, to take on additional functions, including bird harassment.

Similar efforts are underway in Dubai at the Al Maktoum International Airport, where there is a push to include open standards on safety equipment to spawn innovation in the integration of various tools.

Most incursions are not dangerous in and of themselves, but often point to larger issues in human factors, airport and procedural designs. The most recent statistics from the FAA show an increasing number of incursions at the more than 500 towered airports in the U.S., with the bulk of the incidents categorized by the FAA as "C" or "D," meaning the aircraft at risk had "ample time" and/or distance to avoid a collision or where there were no immediate safety consequences, respectively (see page 64). Category A and B incursions, where an accident was narrowly avoided or evasive actions were needed, are very rare events. The FAA's safety target this year is fewer than 20 A and B incursions in 50 million operations.

A recent Cat. C incursion illustrates the norm and how technology can help. A Boeing 787 landed in San Diego last April and did not fully clear the runway before stopping. The Airport Surface Detection Model X (ASDE-X), a surveillance system that fuses ground radar and other sources to drive safety logic that issues alerts, flagged the problem to controllers, who ordered a Boeing 737 on the same runway to abort its takeoff roll before a serious encounter could occur. Errors can also occur when air traffic control procedures are mismatched with new developments in aircraft.

Last April, two pairs of Airbus A380s were involved in Cat. C incursions in the same location at the Los Angeles International Airport five days apart. In both cases, one A380 that had just landed was incorrectly instructed to use a taxiway that did not provide the required separation from a second A380 taking off on the runway that parallels the taxiway.

Boston Logan, which opened in 1923, has not recorded a Cat. A incursion since 2005, but has seen an increasing number of relatively less risky Cat. C events over the past five years. Given its age, the airport has a complex configuration that the operator, the Massachusetts Port Authority (Massport), and the FAA are detangling in parallel with new or upgraded technical and procedural interventions.

According to the FAA's Aviation Safety Information Analysis and Sharing (Asias) database, Boston recorded a rate of 33 incursions per million operations in 2010-14, higher than the overall average of 26 incursions per million operations for all U.S. towered airports. The rate for airline and air taxi operations, at 28 incursions per 1 million operations, was approximately twice that of the nationwide average, according to Aviation Week's computations.

Attempting to drive that number down is a local Runway Safety Action Team effort between Massport, airlines and the FAA. Input from the national level is coming through the FAA's Comprehensive Review and Assessment (CARA), which, with a runway safety action team, is developing targeted interventions in terms of layout geometry, technologies—including an optimal mix of existing and new Runway Status Lights—and air traffic control procedures. "We see [CARA] as a road map or vehicle to get us to that next stage of improvements," says Flavio Leo, Massport's deputy director of aviation planning and strategy.

Runway Status Lights (RWSL) use input from ASDE-X to control lights along the runway centerline at the departure point and at intersections and the runway end. The lights turn red when the runway is occupied. FAA incursion reports do not list any RWSL "saves" for Boston, but an incident in Dallas-Fort Worth in December shows the value. An Embraer 175 had been cleared for takeoff on Runway 17R, but the pilots reported that the RWSL embedded in the runway centerline had lit up red and they halted. It turns out that a Bombardier CRJ900 waiting to cross the runway had taxied over the "hold" line before stopping, potentially impinging on safety margins with the departing E-Jet.

Boston was also a site for testing of another ASDE-X-driven technology known as enhanced final approach runway occupancy signal (eFaros), which causes the precision approach path indicator (PAPI) lights that give pilots a reading of approach slope to flash if the active runway is not safe for landing.

"When we look at concerns like in-

cursions, there is not a single cause or solution," says Leo. Because of its runway configuration and network of legacy taxiways connected to those runways, part of the solution has been to remove taxiways, adjust intersections and build a new taxiway between two parallel runways. Leo says Massport is discussing with the FAA how to "further optimize" the RWSL system, for which the airport paid construction costs; the FAA paid for the lights, software and safety logic. Through CARA, the airport is also considering changes to the geometry, technologies and air traffic control tower procedures.

Boston has also been a pathfinder for other technologies directly related to runway safety, including Automatic Dependent Surveillance-Broadcast (ADS-B) tracking for ground vehicles and automated foreign object debris (FOD) detection.

The airport has 75 vehicles equipped with ADS-B transponders to provide the airport control center with vehicle locations. In the vehicles, drivers have tablets that show the same information on a moving map, boosting situational awareness. "We know exactly where our assets are for snow management," says Leo. Boston as of the end of February had received more than 100 in. of snow.

A FOD detection system built by Xsight Systems has been operational on Runway 9/27 at the airport for more than one year, the first of its kind to be installed at a U.S. airport. Selected through a competitive bid, Xsight's FODetect comprises 68 electro-optical and millimeter-wave radar sensor packages collocated with the runway edge lights placed at 200-ft. intervals along the 7,000-ft. runway. The system is designed to scan the entire runway surface for FOD at 1-min. intervals between operations, sounding an alert in the airport operation center if an object is detected where one should not be. Operators see an icon on a map denoting the FOD and can take control of the articulating and zooming cameras to obtain more information on the object, and if needed, dispatch a crew to inspect or shut down the runway. Airport staff will generally inspect a runway visually by vehicle at least once per shift, or three times per day. The FAA is running a test through June comparing what is being found by FODetect versus the legacy method, and the airport continues to analyze the cost-benefit case.

SEARIDGE TECHNOLOGIES

Searidge Technologies says its traffic lighting system in Dubai is one of the first runway safety tools to feature open standards.

"We are finding stuff," says Leo, leaving out the details. "It's quick, and we can validate it," he says of the system, noting the airport is still in "learning mode" with the new technology and that the legacy searches of all runways continue. "We tend to very rarely dial back on one thing if we're doing something else," he says. "We're treating it as an additional layer of safety."

Arik Fux, Boston office leader for Xsight, says the system costs $5-6 million to install per runway, but costs can be covered by the FAA's Airport Improvement Program or passenger facility charges. In Boston, Massport and the FAA each paid half the cost, says Leo.

Operationally, Boston may get ideas from Tel Aviv, where an Xsight FOD system at Ben Gurion Airport is used to resolve whether to shut down a runway after a crew reports a bird strike. "If they don't get an alert from the system on remains on the runway, they will continue to keep the runway open," Fux says, adding that the runway had previously had to be shut down after every reported strike.

An added function set to go live on a new FODetect system at the Seattle-Tacoma International Airport later is a bird deterrent that uses speakers to selectively harass birds spotted by the system.

Clever surveillance designs are also the forte of Canada's Searidge Technologies, a developer of "intelligent" video-based surveillance and surface management systems. New runway safety projects include two "focus sites" for a remote situational awareness and zone occupancy system, one at Al Maktoum and another at an unannounced airport in the United Arab Emirates, and a video security system at the Aspen-Pitkin County Airport in Colorado. Operational since last summer, the Al Maktoum system uses remote video and airport surveillance information to generate surface traffic status and predictions for aircraft as well as stop lights for vehicles crossing active taxiways, both measures that boost situational awareness and can reduce incursions.

In Aspen, Searidge designed a thermal camera system to create virtual "hot spots" that will alert airport security when passengers or pedestrians cross into active movement areas, says Alex Sauriol, executive vice president for airport and ATM solutions for Searidge. Sauriol says the airport was having issues with passengers deplaning via stairs and walking into critical areas while taking pictures of the surrounding mountains.

Sauriol says the surface management system at Dubai is unique in that it has "open standards" that would allow other companies to potentially use its sensor data for other safety projects. Open standards are not typical elsewhere, he says, leading to disconnects. "What's not happening is that we're not acting cohesively," he says of the industry. "There's not a formal standard for how to bring technologies together to improve runway safety. Right now, if one company installs runway lights and another company wants to use those lights for an alerting function, they can't," he says.

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Future Events

April 14-16—MRO Americas, Miami.
June 17—Commercial Aerospace Manufacturing Briefing, France.
Oct. 13-15—MRO Europe, London.
Nov. 3-5—MRO Asia, Singapore.
Nov. 3-5—Aerospace Defense Chain, Arizona.

Aerospace Calendar

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April 7—Aerospace Additive Manufacturing Briefing. Palos Verdes, California. See www.infocastinc.com/events/add-aero
April 8—Aircraft Electronics Association. Dallas. See www.aea.net/convention/2015/
April 8-9—SpeedNews Third Annual Aerospace Manufacturing Conference. Southern California. See speednews.com/aerospace-manufacturing-conference
April 9—Royal Aeronautical Society Washington Branch's presentation of the 2015 Transatlantic Leading Edge Award. British Embassy, Washington. See raeswashingtondcbranch.cloverpad.org/event-1865771
April 10—Society of Experimental Test Pilots (SETP) 31st East Coast Symposium. Lexington Park, Maryland. See www.setp.org/symposium/meetings/east-coast/
April 12-14—Routes Europe 2015. Aberdeen, Scotland. See www.routesonline.com/events/174/routes-europe-2015-/
April 13-15—Sea-Air-Space 50th Anniversary. Gaylord Convention Center, National Harbor, Maryland. See www.seaairspace.org/
April 13-16—31st Space Symposium. Colorado Springs. See www.spacesymposium.org
April 20-24—Aero Short Course Program. Double Tree Suites, Seattle. See aeroshortcourses.ku.edu/seattle-washington-2015?i=1
April 21-22—Embry-Riddle Aeronautical University hosts NextGen 101. Holiday Inn Capitol, Washington. See proed.erau.edu, call +1 (866) 574-9125 or email training@erau.edu
April 21-23—2015 International Rotorcraft Safety Conference. Hurst (Texas) Conference Center. See www.faahelisafety.org/registration/
April 24—SETP's Fifth Northwest Symposium. Seattle. See www.setp.org/symposium/meetings/northwest

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**Space edition

Budget Blunders Can't Drive Strategy

REUTERS/LANDOV FILE PHOTO

BY ROBERT O. WORK

Deputy U.S. Defense Secretary of Robert O. Work spoke recently in San Diego about congressional spending caps known as sequestration and strategic decisions. This is adapted from that talk.

The tremendous margin of technological superiority that the U.S. has typically enjoyed since the end of World War II is eroding, and at what we consider to be an accelerated pace.

We're seeing levels of new weapons developments that we haven't seen since the mid-'80s, near the peak of Soviet Cold War defense spending. Russia is modernizing its forces right now, and it was once in a very steep decline.

From 2011 to 2016, we estimate that China's defense budget increased by 500%. Its military is rapidly fielding new weapons and systems. It is astonishing to see the number of programs that they are developing at a single point.

Iran has built up an array of asymmetric capabilities, including mines, missile-firing small boats, ballistic missiles and advanced anti-ship missiles with advanced seekers.

> "The margin of technological superiority the U.S. has enjoyed since World War II is eroding.

North Korea's conventional military power is imposing because of its size, but that worries us less than its growing arsenal of nuclear weapons and road-mobile ballistic missiles that put our allies and forces in the region at risk, as well as, potentially, the U.S.

We're starting to try to reverse the years of underinvestment in new weapons and capabilities. We're making much-needed investments in our nuclear enterprise. Because of the proliferation of guided munitions and other advanced technologies that threaten our ability to project power, we're spending more on what we refer to as counter-anti-access/area-denial weapons. Our space constellation is under more threat now than it has been at any time, so we've increased money for both space resiliency and space control capabilities.

Trying to tackle this erosion of technical superiority was exactly what [Defense] Secretary [Chuck] Hagel had in mind when he announced the Defense Innovation Initiative in November. It's a department-wide effort to identify a third offset strategy, or perhaps more accurately, offset strategies, in order to sustain and advance our military technological edge into the 21st century.

We will also seek to identify new concepts of operations, just like we did in the Cold War, with air-land battle and the maritime strategy. Now, doing this is going to be really difficult, again, for three big reasons:

- First, we no longer face a single implacable foe like we did in the Soviet Union.
- Second, we find ourselves in a very different competitive environment. In the 1950s and 1960s, we were spending a lot of money on missiles, on nuclear weapons, the early computer age. In the '60s and '70s, we started putting money into space. It was all generally government-driven. But today, commercial adaptation and commercial innovation—robotics, autonomous operating guidance and control systems, new ways of visualization, biotechnology, miniaturization, advanced computing, big data and additive manufacturing like 3-D printing—all of those advances are being pushed primarily in the commercial sector.
- Third, technology diffusion is likely to impact the durability of the advantage. Our first offset strategy, which we started in the 1940s, lasted until 1975. Our second offset strategy extended from about 1975 to now. We are talking decades. Now, with the pace of change and with commercial technology changing so often, the third offset strategies will have a far more challenging temporal component in the competition.

So, you'll see in the fiscal 2016 budget some really potentially game-changing technologies that we think can more quickly get to the forces. And you'll see more long-range research efforts. For example, we're investing more in unmanned underwater vehicles, high-speed strike weapons, railguns and high-energy lasers.

Some of the time, some of the things we're doing in our budget will not be readily apparent, but let me tell you, the things that we are doing are going to greatly complicate any adversary's attempts to fight against U.S. forces.

Our job is very simple. That mission is to organize, train and equip a joint force that is built and ready for war and operated forward to preserve the peace. Everything else that we do, if it's not focused on that mission, it's a damn waste of time.

If you total up the amount of money in fiscal 2016-20 [that the Obama administration proposes to spend on defense] and compare it to the sequestration caps, our submission is about $150 billion higher than sequestration. But let me make clear, even though we're about $150 billion above the sequestration caps in our request, maintaining the balance between personnel, readiness and modernization is extremely challenging.

Sequestration is a blunder that allows our fiscal problems, not our security needs, to determine our strategy. We [offer] a strategy-driven, resource-informed budget. But if you want a budget-driven strategy, go to sequestration.

Schedule at a Glance

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(separate registration required)

8:00 a.m. - 5:00 p.m.
Registration

2:00 p.m. - 5:00 p.m.
Marketing Services Briefing
(There is no fee for the Briefing but registration is required.)

TUESDAY, APRIL 14

7:30 a.m. - 5:30 p.m.
Registration

8:30 a.m. - 1:15 p.m.
Conference Sessions

1:00 p.m. - 5:30 p.m.
Exhibition Hall Open

WEDNESDAY APRIL 15

7:30 a.m. - 5:30 p.m.
Registration

8:30 a.m. - 1:00 p.m.
Conference Sessions

9:30 a.m.- 5:30 p.m.
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4:00 p.m. - 5:30 p.m.
MRO Birthday Bash at
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THURSDAY APRIL 16

8:00 a.m. - 2:30 p.m.
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9:00 a.m. - 12:35 p.m.
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