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

64 *The European Space Agency developed this concept for a Moon base, 3-D-printed with lunar regolith as feedstock. NASA is meanwhile working on a long-term plan for a journey to Mars.*

ON THE COVERS

This week, Aviation Week publishes two print editions. The cover far left highlights the dilemma facing leaders of the world's space agencies as they gather for the International Astronautical Congress in Jerusalem—whither human spaceflight after the International Space Station era (page 64)? NASA illustration. Elsewhere in both editions are reports on Bombardier's C Series (page 28), labor strife at Air France (page 21) and the Cobra attack helicopter (page 45). On the cover of our Defense Technology International Edition, the 680-ton forward island of the second of the U.K.'s new carriers, HMS Prince of Wales, arrives at the assembly dock in Rosyth, Scotland. Aircraft Carrier Alliance photo. Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*

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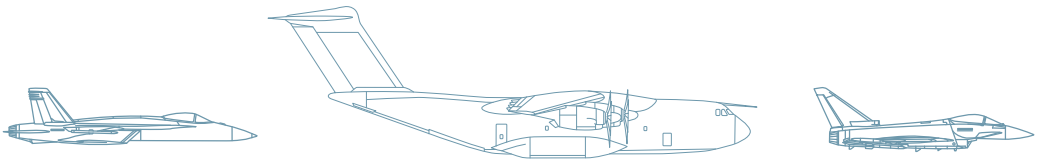


Feedback

Aviation Week & Space Technology *welcomes the opinions of its readers on issues raised in the magazine. Address letters to the Executive Editor, Aviation Week & Space Technology, 1911 Fort Myer Drive, Suite 600, Arlington, Va. 22209 or send via email to:*
awstletters@aviationweek.com
Letters 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.

ILL-SUITED ANALOGY

The recent Up Front commentary "If a Weapon Were a Three-Piece Suit" compares defense acquisitions to buying a suit (*AW&ST* Sept. 14-27, p. 12). Clever, perhaps, but it is a poor analogy.

The requirements for a suit are well known and the item is delivered for use within a short time, whereas requirements for defense articles are unknowable in detail because of their complexity, the environment in which they operate, and the time between specification and operation.

Sid Koslow
ANNANDALE, VIRGINIA

'TMI' COMPLAINT

In a recent online ad for subscriptions you wrote: "Where is the boundary between classified intelligence and reporting? For decades, we have pushed this to the limit, proudly earning the title of 'Aviation Leak.'"

Gee, thanks. You give our enemies the technology they need to defeat us in war. Isn't that treason? Our nation has to spend billions more in defense because you leak information.

Brad Stanton
WICHITA, KANSAS

ANOTHER SPIN ON SPIN-GRAVITY

This taxpayer wishes NASA would take to heart Robert Salvage's Viewpoint: "Artificial Gravity, Real Solution" (*AW&ST* Aug. 3-Sept. 13, p. 74).

NASA's rationale for physiology studies aboard the International Space Station asserts we need a zero-g facility in order to learn how to live in zero-g—which makes the ISS sound like a $100 billion self-licking ice cream cone.

Crews conducting zero-g lab experiments should live in an adjoining spin-gravity facility, entering the labs and subjecting their bodies to zero-g only briefly, to avoid its ill effects.

Reader (and NASA scientist) Gilles Clement's objection (*AW&ST* Sept. 14-27, p. 8) that "Scientific studies are required to establish" parameters for spin-gravity, is exactly why such a facility must be built. Earth-based studies cannot answer such questions.

Nor does the goal of sending people to Mars justify zero-g living: For years, no serious proposal for such missions has suggested zero-g interplanetary travel. Even NASA's own Reference Missions assume spin-gravity en route, of the type advocated by Salvage, with two masses spinning on the ends of a long tether.

However, beginning with such a facility in Earth orbit only for physiological studies would be extremely costly and offer little benefit to other goals. Despite Salvage's pessimism, a complete spinning-wheel station may be justified. Rather than replicating full Earth gravity, such a facility could be used for mission risk reduction, enabling high-fidelity studies of both physiology and equipment in Mars (or lunar) equivalent gravity.

How the human body will fare in partial gravity is unknown; this is what we must find out before undertaking multiyear missions to Mars. With a zero-g adjunct, such a station could serve multiple constituencies and thereby gain the support needed to build our next station.

John Cserep
VALPARAISO, FLORIDA

SHOUT-OUT TO FORWARD THINKERS

I was very much taken by the examples of airborne schlieren photography (*AW&ST* Sept. 14-27, p. 64). I wondered who had thought of the technique, something not stated in the article. In a similar vein, I then recalled that I also needed to look up the name of the original designer of the C-130 as it is not a household name, as it should be. Willis Hawkins proposed it and designed it.

We learn too little about many of the people who have the original ideas in aerospace. So who came up with the idea of "live" schlieren photography?

John C. Bauer
MANOTICK, ONTARIO


SUPERSONIC RESEARCH

Seen As Well As Heard

Guy Norris Los Angeles

These remarkable images of supersonic shock waves emanating from a U.S. Air Force T-38C were captured by a NASA Beechcraft King Air 200 equipped with a high-speed camera. The test was conducted as part of the latest phase of the agency's Air-to-Air Background-Oriented Schlieren (AirBOS) program, which aims to develop techniques for seeing real shock-wave geometry in the atmosphere.

The technique could play a key role in validating design models for NASA's proposed low-boom supersonic demonstrator, and because it visualizes shock waves through temperature and humidity gradients, it provides data that cannot be duplicated in wind tunnels.

The technique works by photographing the passage of the target aircraft directly below the camera-carrying aircraft against a speckled background—in this case, the natural sage brush and scrub of California's Mojave Desert. The images, captured at a rate of 1,000 frames per second for the level pass and 1,400 frames per second for the banked pass, are processed and shock waves are deduced from distortions of the background pattern caused by changes in the refractive index due to density gradients. ●

The concept of taking a schlieren image of a flying aircraft (as opposed to a wind-tunnel model) was developed by NASA Langley researcher Leonard Weinstein in the early 1990s. He and colleagues at NASA Dryden (now Armstrong) Flight Research Center—David Richwine, Geoff Miller and others—further developed the idea to capture images of a flying aircraft from a second aircraft. The technique of taking airborne schlieren images against speckled backgrounds was put forward by Dan Banks at NASA Armstrong and J.T. Heineck of NASA Ames. The concept of using speckles on the Sun (background-oriented schlieren using celestial objects) was developed by Armstrong's Ed Haering.—Editor.

RELEARN THIS LESSON

I went to the Miramar, Florida, air show earlier this month where, as usual, the U.S. Navy's Flight Demonstration Sqdn.—better known as the Blue Angels—maintained their impeccable standard of flying. The formations were rock-solid.

Evidently, the organizers are too young to remember John Derry, who specialized in high G turns. At the 1952 Farnborough Airshow he did a 6g "roll with pullout" turn and put some of the heavier parts of the aircraft into the crowd, killing about 30 people, including himself and his flight observer. Subsequent British air show rules forbade all maneuvers toward spectators.

Regrettably, our team did this procedure—twice. I cringed.

Lew Creedon
OCEANSIDE, CALIFORNIA

POSITIVE ID

The pilot shown with Kelly Johnson (*AW&ST* Sept. 14-27, p. 40) is Francis Gary Powers, not Tony LeVier.

Donald A. Moor, Lockheed Test Pilot (ret.)
SHINGLETOWN, CALIFORNIA

Who's Where

Renee Wynn

Kenneth Robinson

Giulio Ranzo

Ralph Crosby

Rebecca Stahl

Lawrence Ryan

Robert Gaag

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

NASA has named **Renee Wynn** (see photo) chief information officer. She will be responsible for strengthening the agency's IT security and ensuring that information asset procedures are in line with all federal policy requirements. Wynn replaces Larry Sweet, who has stepped down.

Northrop Grumman has appointed **Kenneth Robinson** (see photo) vice president-operations, intelligence, surveillance and reconnaissance (ISR), McLean, Virginia. Robinson has been the director of national and military systems operations for the ISR division and previously served with the U.S. Air Force Space and Missile Systems Center, Los Angeles.

Giulio Ranzo (see photo) has been named CEO and general manager and **Pier Giuliano Lasagni** vice chairman, with responsibility for business development and new strategies at *Avio*. Lasagni is retiring as CEO.

Gilberto Lopez Meyer has been named senior vice president-safety and flight operations and **Nick Careen** senior vice president-airport, passenger, cargo and security at the *International Air Transport Association* (IATA). Lopez Meyer was director general of the Mexican Civil Aviation Authority. He succeeds Kevin Hiatt, who left IATA in July. Careen was most recently vice president-airport, call centers and customer relations at Air Canada He succeeds Tom Windmuller, who retired in August.

Francois Lassale has been chosen as *HeliOffshore* operations director. Lassale, a seasoned rotary- and fixed-wing pilot, brings military and corporate experience gained in Africa, the Middle East, Europe and the U.S. to the London-based global safety association for the offshore helicopter industry.

Airbus Helicopters has named **Ralph Crosby III** (see photo) executive director-corporate and VIP sales. Crosby will lead the company's efforts to develop a U.S. market and assist Airbus Helicopters Canada. He had been vice president-sales at *Dallas Jet International*.

Rebecca Stahl (see photo) has been appointed CFO-accounting and human resources for the *Association for Manufacturing Technology*, McLean, Virginia.

Kenichi Inukai has been named senior vice president-airworthiness and type certification by *Mitsubishi Aircraft Corp.*, Nagoya, Japan.

Inmarsat has appointed **Frederik van Essen** vice president-aviation strategy and communications, based in Nyon, Switzerland, near Geneva. He will oversee business planning for Inmarsat's fast-growing aviation division.

Lawrence Ryan (see photo) has been appointed *Lufthansa Group*'s U.S. sales director. He succeeds **Don Bunkenburg**, who is now *Lufthansa German Airlines*' general manager for Japan.

Robert Gaag (see photo) has been appointed *Lufthansa Technik* senior vice president-corporate sales for Europe, the Middle East and Africa. He had been vice president-sales, North America.

Rear Adm. **Lawrence B. Jackson** will be assigned as director, strategy, policy, programs and logistics, J4/5, *U.S. Transportation Command*, Scott AFB, Illinois. Jackson is currently serving as reserve deputy director, Warfare Integration Division, N9I, Office of the Chief of Naval Operations, Washington.

Aspen Avionics has appointed **Steve Lawson** regional sales manager, Western U.S. and Canada, and **Charlie Reiche** field service engineer, Central U.S. The company specializes in advanced display and sensor technology.

FlightSafety International has promoted **Jeff Rose** to manager of the company's Learning Center in Atlanta. He succeeds **Ed Klonoski**, who has retired.

AeroMobil has announced the appointment of **Ian Bacon** as program manager for the development of a flying-car prototype.

Ryanair has made several senior appointments: **John Tuite** has joined as head of finance; **Eamonn Hackett** has been named group treasurer, with oversight of all treasury and banking functions; and **Greg O'Gorman** has been named director of ancillary revenue. Tuite had been with the *Bank of Ireland* and O'Gorman had been with *EasyJet*.

Laura Jennings has joined *Dentons*' Washington-based litigation and dispute resolution practice. Jennings had been senior trial attorney, Office of the General Counsel, Aviation Enforcement and Proceedings Division at the Transportation Department.

English Field Aviation has promoted **Jamison Adams** to account manager and appointed **Scott Latino** as avionics manager at its Amarillo, Texas, facility, where it specializes in King Air aircraft maintenance and refurbishment and avionics upgrades.

Stephen Pope has been named editor-in-chief of *Flying* magazine. Pope's new role will include leading a print redesign as well as a relaunch of flyingmag.com.

HONORS & ELECTIONS

The National Aeronautic Association has selected aerospace engineer **Burt Rutan** to receive the 2015 Wright Brothers Memorial Trophy for originality in designing energy-efficient aircraft. These include the record-breaking Voyager, the first aircraft to fly around the world without stopping or refueling, and the suborbital Spaceship One spaceplane, the first privately funded spacecraft to enter space twice in a two-week period. Rutan also has five aircraft on display at the Smithsonian's National Air and Space Museum in Washington.

U.S. NAVY

DEFENSE

The second of three at-sea development-test (DT) phases for the U.S. Navy's Lockheed Martin F-35C began on Oct. 2 when two test aircraft, CF-03 and -05, landed on the aircraft carrier USS Eisenhower off the U.S. East Coast. The two-week DT-II phase follows DT-I in 2014.

The U.K. will purchase an upgraded General Atomics MQ-9 Reaper to meet its Protector requirement for 20 medium-altitude, long-endurance unmanned aircraft to replace its fleet of 10 Block 1 MQ-9s by the end of the decade. Adverse-weather operation and sense-and-avoid are likely requirements.

BLR Aerospace is pitching an upgrade program to extend the life of Bell AH-1 Cobra attack helicopters still in service with several countries. Beyond its FastFin retrofit to improve anti-torque capability, the company is offering oil cooling, an inlet barrier filter and structural upgrades (page 45).

Boeing's first fully equipped KC-46A Pegasus tanker test aircraft made a 4-hr. first flight on Sept. 25 from Paine Field, Washington. Aircraft EMD-2 carries Cobham-supplied wing-mounted refueling pods and a centerline hose-and-drogue system, as well as a Boeing-designed refueling boom.

BOEING

Development of a new engine for the Boeing AH-64 Apache and Sikorsky UH-60 Black Hawk has been launched by the U.S. Army with release of the request for proposals for the Improved Turbine Engine Program. The 3,000-shp-class turboshaft will replace General Electric's T700.

COMMERCIAL AVIATION

The future of the C Series is in question after Bombardier and Airbus both announced Oct. 7 that they had ended talks on "business opportunities." Reuters reported Airbus had been offered a majority stake in the program. Analysts warn the Canadian manufacturer could run out of cash to complete development and ramp up production of the airliner (page 28).

Air France is to cut 2,900 jobs, close routes, reduce frequencies and scale back its long-haul fleet—mainly by accelerating retirement of Airbus A340s without replacing them with Boeing 787s as planned—in a bid by Air France-KLM to reduce its unit costs by an average of 1.5% a year in 2015-17.

Japanese regulators have approved plans for a new Air Asia low-cost-carrier joint venture, which plans to launch international and domestic services from Nagoya in spring 2016. Air Asia Japan is its second attempt to start a low-cost franchise in the country after a venture with All Nippon Airways was dissolved in 2013.

A company photographing vacant properties faces the biggest fine yet for operating unmanned aircraft recklessly. The FAA has proposed a $1.9 million civil penalty against SkyPan for conducting 65 flights between March 2012 and December 2014 in airspace near airports in New York and Chicago.

Finnair is betting on the Airbus A350 to reach the target of doubling its traffic and revenue on routes between Europe and Asia by 2020,

AIRBUS

from 2010 levels. The Helsinki-based carrier on Oct. 7 became the first European airline and third worldwide to take delivery of the A350-900.

Technology to detect unmanned aircraft within 5 mi. of airports is to be evaluated by the FAA under a research program with developer CACI International. The system will detect radio signals to the UAV and track them back to the operator, and it is to be tested at airports in Virginia.

Virgin Atlantic Airways, which has so far viewed the Airbus A350-1000 as the front-runner for its large-twin, long-haul requirement, says it is considering used Boeing 777-300ERs as it evaluates its fleet renewal. The airline cites reduced lease rates and low fuel prices (page 30).

Pilots of a Trigana Air ATR 42-300 that crashed near the top of a ridge on approach to Papua, Indonesia's Oksibil Airport on Aug. 16 were not following the airline's visual guidance

First Take

approach to the airport, according to a preliminary report by Indonesian investigators. All 54 passengers and crew were killed.

Texas Aero Engine Services (Taesl), a 50-50 joint venture between Rolls-Royce and American Airlines, is to close in January at the request of the engine manufacturer. Fort Worth-based Taesl was established to overhaul Tay and RB211 engines, but demand is declining as those aircraft leave American's fleet.

SPACE

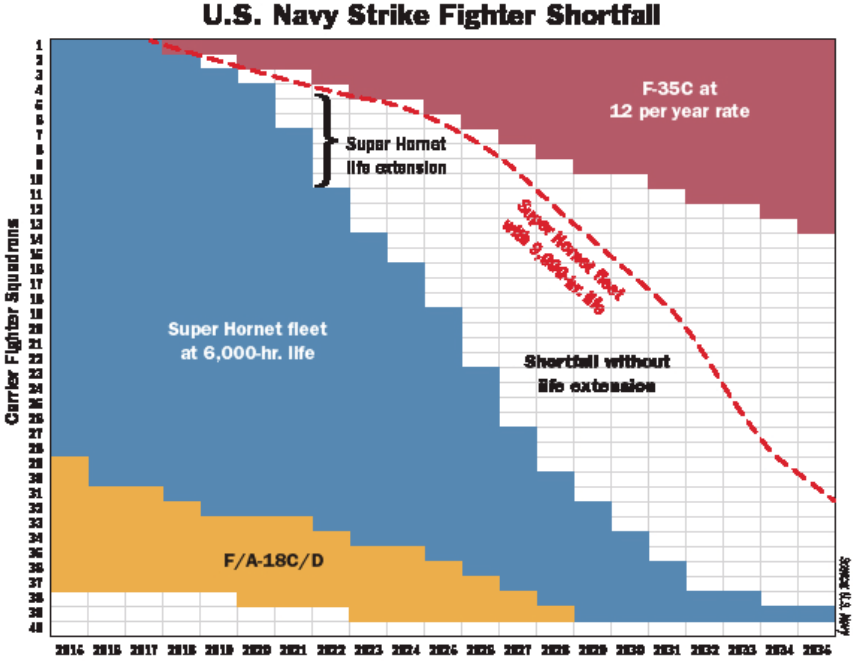
Congressional restrictions on buying RD-180-rocket engines from Russia for its Atlas V launch vehicle could force United Launch Alliance to bid against new rival Space X for a U.S. Air Force GPS III launch in 2018 without an engine. This is the first of nine launches to be competed (page 34).

Antrix, commercial arm of the India Space Research Organization, has been ordered by an international tribunal to pay $672 million in penalties for canceling a deal to lease satellite capacity to Devas Multimedia—a major embarrassment for the agency as it tries to gain a foothold in the space market.

Sierra Nevada Corp. will deliver its repaired Dream Chaser engineering test article to NASA Armstrong around year-end, to resume atmospheric drop testing in the first quarter of 2016. Three to six flights are planned, beginning with a repeat of the 2013 helicopter drop test then towed by an aircraft to higher altitude.

SIERRA NEVADA SPACE SYSTEMS

The U.S. Air Force has declared operational two satellites designed to collect images of other spacecraft in geosynchronous orbit. Built by Orbital ATK and launched in July 2014, the Geosynchronous Space Situational Awareness Program satellites were declared operational on Sept. 29.



U.S. Navy strike fighter squadrons will fall below strength in the 2020s without a major service-life extension program for the Super Hornet. This Navy graph shows one scenario with a budget-constrained F-35 buy.

14 YEARS AGO IN *AW&ST*

Russian officials admitted to Aviation Week that they were using remains from a U.S. Air Force F-117 shot down during the 1999 Kosovo campaign to improve the ability of their air defense systems to detect and kill stealth aircraft. The scoop, reported from Moscow by editors David A. Fulghum and Robert Wall and published in the Oct. 8, 2001, edition of the magazine, noted that only sections of the F-117 had survived intact, hampering the Russians' goal of determining how radar energy was dissipated over the entire aircraft. The article added that Russia was pursuing a wider campaign to defeat stealth, an effort that continues to make strides in 2015.

Read the original article on the Russian use of F-117 remnants to defeat stealth and about other momentous events in aerospace history at: **AviationWeek.com/100**

Anthony L. Velocci, Jr.

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

COMMENTARY

Invisible Barriers

Sole-source contracts need to be restricted

Congress, the Pentagon and the Government Accountability Office (GAO) have been clamoring for years that increased competition is the most effective way to reduce wasteful defense spending. Yet the practice of awarding contracts on a sole-source basis is pervasive throughout the Defense Department. In fact, about half of the $3 trillion the department expects to spend during the next decade on just maintenance and operations will involve sole-source contracts, according to the Pentagon's own Competition Reports.

LOCKHEED MARTIN

The Defense Department's justification is that only original equipment manufacturers (OEM) hold the technical data to perform the maintenance. But here's the rub: When potential competitors are shut out, the work almost always goes to the OEM, effectively giving it a lifetime monopoly.

A good example is replacement parts for the propeller for legacy Lockheed C-130 transports. They have been sole-sourced for 60 years to Hamilton Sundstrand, a part of United Technologies Corp.'s Aerospace Systems (UTAS), at a cost of hundreds of millions of dollars. Now the same OEM is replacing the propeller with one that likely will extend the monopoly another 20 years.

Worse, UTAS won't release the maintenance manuals for the replacement prop, even though the propeller could be maintained by any one of numerous maintenance, repair and overhaul (MRO) providers, possibly at less cost. The net result is that UTAS effectively will be assured of a protected revenue stream throughout the propeller's entire life cycle. The irony is that while Defense Secretary Ashton Carter and weapons acquisition chief Frank Kendall bemoan the upfront price of weapons systems, the reality is that the life-cycle cost of military hardware is 2-3 times as much.

Even when some independent companies have expressed a willingness to foot the bill to develop maintenance manuals and replacement parts—potentially saving the Pentagon huge sums of money—the government has still been inclined to turn a blind eye. In some cases, it has claimed there are insufficient resources to approve newly developed manuals and replacement parts; in other cases, it has indicated no desire to follow up.

First Aviation Services Inc. knows the drill all too well. For the last three years, the small supplier has been trying to unbundle the multibillion-dollar, sole-source contract that the Defense Department has been awarding to Rolls-Royce annually since 2000.

If technical data is the issue, the solution is obvious: Enforce existing laws that mandate the government has unlimited rights to repair and maintenance data, including the right to provide it to third parties for all routine maintenance. But if it is a case of institutional bias in favor of OEMs, that may present a more intractable problem—not just for First Aviation but for all lower-tier suppliers that would like to compete for MRO contracts being awarded on a sole-source basis. In either case, current practices make a mockery of the Pentagon's mantra of "do more with less."

In an unexpected twist, multiple protests by First Aviation not only revealed that Rolls outsources essentially all the work to subcontractors, but the Defense Department has taken delivery of hundreds of C-130Js without obtaining FAA airworthiness certificates, despite Pentagon budget requests to Congress describing the aircraft as "FAA-certified." According to an FAA legal opinion, if the Pentagon had not failed to obtain these certificates, it would have immediately clarified any legal question about the Pentagon's rights to technical data and opened up to competitors all maintenance contracts for the "J" model.

There are signs that First Aviation is making some headway. For example, Congresswoman Virginia Foxx (R-N.C.), a defense hawk, is urging the House Armed Services Committee and her colleagues to pressure the Defense Department to enforce laws restricting sole-source contracts. This is smart, since the implications of First Aviation's protests are gargantuan when applied to hundreds of billions of dollars in defense spending over the next 10 years. Potential savings almost certainly would flow from opening up MRO contracts to full and open competition, too.

First Aviation is just a microcosm, however. No doubt, countless other suppliers run into the same invisible barrier year after year. Setting aside the issue of fairness or even the legalities in government contracting, the issue begs the question of whether Defense Department leadership is serious about challenging the status quo and traditional ways of doing business to improve the affordability of weapons systems.

If it is—though there's good reason to be skeptical—OEMs in the short term will lose lucrative sustainment annuities. On the plus side, the savings and benefits generated by full and open competition might actually be the key to accommodating much needed weapons systems modernization.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BOEING

By Michael Bruno

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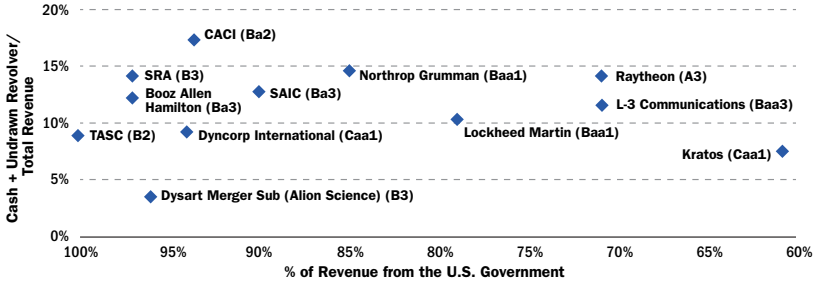
COMMENTARY

Debtors' Prison

The next manufactured crisis on Capitol Hill could hit the A&D industry doubly hard

The ghost of Christmas past is about to descend on the Western aerospace and defense (A&D) industry this fall—and this time, believe it or not, it could be even worse.

A&D Companies Most Exposed to Debt Debate



Note: Moody's corporate family ratings are shown in parentheses. *Source: Moody's Investor's Service*

Unlike the Sept. 30 end-of-fiscal-year deadline that passed uneventfully due to House Speaker John Boehner's decision to leave Congress this month, the next manufactured deadline of Dec. 11 could be a real grudge match. Not only will it be the first appropriations deadline post-Boehner, it will also come with another unresolved fight: raising the federal debt ceiling.

On Oct. 1, Treasury Secretary Jack Lew officially warned Congress the current $18 trillion limit needs to be raised by Nov. 5. That is also about when a new, less-experienced House Republican leadership could take over the lower chamber, assuming Boehner (R-Ohio) does not resolve the debt issue before leaving office.

The prospect of a government shutdown alone, as happened in October 2013, recalls horrific consequences for the A&D sector. Remember the furloughed air traffic controllers, canceled or delayed flights—this time possibly over the holidays—and stressed-out Defense Department workers? Congressional inaction on the debt ceiling will amplify the effect on industry.

If a new debt ceiling is not approved, at least some federal contractors waiting to be paid for work already billed may have to keep waiting. That is because the government could have to decide which bills to pay: A fifth of everyday U.S. operations are fueled by debt. No new debt issuance means 20% less money would be available to pay bills, literally overnight.

Past precedent and recent comments by Washington insiders are offering insight into what could happen. One is former Pentagon Comptroller Robert Hale, now an adviser to major services contractor Booz Allen Hamilton. He was the chief financial officer at the Defense Department 2009-14 and oversaw the Pentagon's response to sequestration implementation and the 2013 government shutdown.

Hale tells Aviation Week how, during the last debt-ceiling crisis in early 2014, the White House and Treasury did not volunteer details on what would happen if they could not issue new debt. In turn, he and others in the government expected Treasury would pay all the bills it could on the first day and then wait to see what happened the next day. That suggests the plan was to watch stock market reactions and see if Congress responded by passing a new ceiling. "Things would just get generally later," Hale says. "This is a terrible idea."

If you're still in doubt, look no further than the automatic, across-the-board sequestration cuts to budget authority that took hold in March 2013 or the October 2013 shutdown. Politicians loathe publicly choosing winners and losers, so it is easier to just let every agency and contractor suffer equally.

However, not everyone in industry may suffer the same. In September, Moody's Investors Service released its latest Defense Contractor Liquidity Index report, which scores the vulnerability of rated U.S. defense contractors to disruptions in government payments. The index is based on calculations of a company's sources of near-immediate liquidity relative to estimated annual government-related revenue, with scores serving as a proxy for measuring relative liquidity exposure to a complete cessation of government spending.

Some of the conclusions from Moody's latest report include:

- The "most-exposed" companies now comprise a third of the A&D universe, with 22 companies (34% of the ones that Moody's rates). That is up from 21 companies, 32%, in 2013, "reflecting high exposure to U.S. government contracts and/or relatively less-robust liquidity profiles."
- Companies that exited the "most exposed" group since the last report in 2013 include Artel, Orbital ATK, Leidos and Huntington Ingalls Industries. Contractors added this year include Raytheon and Northrup Grumman.
- While industry overall has improved, gains have been mostly realized by commercial aerospace companies.
- Among investment-grade contractors that derive at least half of their revenue from Washington, liquidity as a percentage of U.S. government-based revenues has mostly risen.
- The average score for speculative-grade defense contractors fell due to lower-scoring newcomers joining the 2015 index, including Constellis Holdings, Michael Baker Holdings, Pacific Architects and Engineers, and Science Applications International Corp.

Americans can argue the merits of raising the debt ceiling, but for industry, the impact is clear.

By William Garvey
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COMMENTARY

Trainer Taking Off

An aircraft manufacturer builds classrooms and sims

When it acquired Beechcraft and Hawker and combined those with Cessna in 2014, Textron Aviation and its plans for aircraft manufacture, support and development quite rightly drew lots of interest from the business aviation community. First, the Citation Latitude appeared, service centers were combined and speculation began over new models of turboprops and jets.

TEXTRON

But it turns out that Textron Inc. has an even broader aviation reach in mind.

As it was weighing a bid for Beech-Hawker, the Providence, Rhode Island, conglomerate's aviation stable, in addition to Cessna, included Bell Helicopter, Lycoming engines, McCauley propellers and AAI, an aerospace and defense company that made UAVs and military aircraft simulators, among other things. And it hungered for more.

So, in late 2013 it acquired Mechtronix Inc. and Opinicus Corp. both flight simulation and aircraft training product companies, based in Montreal and Lutz, Florida, respectively. A few months later, it combined AAI, Mechtronix and Opinicus under the new, albeit strained, label, TRU Simulation + Training Inc. And to that in July 2014 it added ProFlight, a pilot training outfit in Carlsbad, California, that focused on Cessna Citations.

This new, other-than-airplanes aviation division of Textron has been giving good measure of its intentions. At the Paris Air Show in June, it announced the imminent installation of a Citation CJ3 Level D simulator in Germany, the first in Europe. In July, it announced the first Level D Twin Otter sim as well as a collaboration with Bell to build a Bell 525 sim.

But the most dramatic display of direction came Sept. 28 when it held the grand opening of a new ProFlight training center (see photo above) outside Tampa, Florida. The new center will offer type rating and recurrent training for pilots, along with enrichment courses. At its start, the center will focus on Citation CJ models using a Level D simulator and advanced training devices, but plans call for expanding into additional Cessna and Beech models.

And, the company says, work is underway in Valencia, Spain, where a new training center is planned for Bell's 429 and 525 Relentless helicopter models, with target start dates of 2016 and 2018, respectively. According to the company, more centers are likely.

Despite its steady, deliberate growth, the new Textron unit is not likely to challenge the training leadership of either FlightSafety International or CAE, which combined have hundreds of simulators for aircraft ranging from utility helicopters and business jets to military and civilian transports housed in centers around the world. To underscore that lead, FlightSafety, which was first designated Cessna's factory-authorized training organization in 1979, will soon have a fleet of 47 simulators representing all Cessna turbine models in training centers in the U.S. and the U.K.

SUPERSIZED FBO

The consolidation of fixed base operators (FBOs) is taking a giant step forward with BBA Aviation. The British owner of Signature Flight Support (see photo below) recently announced plans to acquire Landmark Aviation from the Carlyle Group for $2.1 billion. The deal is a pairing of business aviation servicing giants, since Signature already operates 133 bases and Landmark 68.

BBA Aviation CEO Simon Pryce calls the move "strategically and financially compelling" and allows Signature to "materially expand" globally.

Thomas Hendricks, president of the National Air Transportation Association, which represents FBOs, along with charter operators and fuelers, says that the increasing efficiency and range of business jets are factors in the consolidation movement and that "the flowage of Jet A [fuel] is kind of driving this."

Meanwhile, competing independents complain that the big chains' economies of scale in fuel purchasing and discounting for regular customers at the multiple locations gives them an edge in the marketplace. Many well-known names have sold out and exited the market altogether as a result.

BBA AVIATION

If the deal survives antitrust scrutiny by regulators, it could close in 2016.

By Jens Flottau

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COMMENTARY

Over the Fence

Air France managers are attacked for proposed cutbacks—but even more winnowing is needed

Imagine this: Company management meets with employee representatives after negotiations about efficiency measures have failed. Shortly after the meeting begins, dozens of angry protesters storm the company headquarters, effectively shutting down the proceedings. A short while later, videos of a shaken human resources (HR) director and another company executive go viral on social media. They depict the drama of the HR executive climbing a fence to escape the mob, his clothes in tatters. Police swoop in, and the managers are rescued.

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It sounds like overwrought fiction, but this is exactly what happened to Air France Executive Vice President of Human Resources Xavier Broseta in Paris in front of the airline's headquarters. The Oct. 5 incident is arguably the worst clash between airline management and labor in recent memory. And according to Broseta's own account of what happened, it was only due to the caution and responsible action of the union leadership that Air France CEO Frederic Gagey escaped unhurt. At one point, shortly before things got out of control, he was asked to leave the conference room because the union felt his safety was no longer guaranteed.

While the violence was immediately criticized by union leaders, it is really just the most dramatic sign of the ongoing existential crisis at Air France. This is probably the death knell for one of Europe's great aviation brands. The company will not disappear altogether, but it will become a shadow of its former self. Its unit costs are by far the highest in Europe's airline industry, but before the Oct. 5 outbreak unions had rejected even modest efficiency measures proposed by management. Some refused to even talk.

The consequences are clear: Air France will cut 2,900 jobs and shrink the long-haul network. Five widebody aircraft are going to be taken out of service next year; another nine will follow in 2017. Also, the airline looks set to cancel an order for 25 Boeing 787s—a potentially painful, although ultimately manageable, setback for the manufacturer.

The unions are well aware of the draconian means being called for. But the truth is, these measures are not nearly sufficient to return the airline to a stable footing. Many more far-reaching decisions are needed.

Jean-Marie Baroux, who is running an airline consulting and services company in Paris, argued in a commentary for *La Tribune* newspaper that because the airline ultimately needs fresh capital, it has to consider discarding some units. Maintenance organization Air France Industries could be a candidate; other airlines have looked at selling their MRO business to generate cash, but in this specific case it may be hard to do because the unit predominantly works for one customer—Air France. Another potential candidate is regional carrier Hop!, but who would buy a business with such unclear prospects?

Baroux even suggested Air France should split from KLM, but it is difficult to see how management would benefit from such an extreme measure, which would reverse the very core of its strategy for the past 10 years.

But interestingly, the Air France crisis, among other things, underscores the trouble with operating expensive hubs. The feeder network is one of the biggest problems the airline is facing. Ironically, the airline may actually still be among the best-placed of its peers to tackle the problem: Paris is such a strong origin/destination market that the flag carrier is less reliant on feed from other markets than some of its competitors including Lufthansa, Iberia or Swiss International Air Lines, let alone its partner KLM. Cutting some of the feed would lead to further shrinking, but it would not undermine the rest of the long-haul network—or at least not as quickly—as it would for carriers that cannot primarily fill long-haul destinations from one big market.

All of this is theory, of course, because such decisions may be seen as being too politically sensitive to be viable.

Speaking of politics, it is important to remember that Air France, through Air France-KLM, is still partly owned by the French government. While interference from the state has been a chronic problem for the airline—it has clearly slowed down its restructuring efforts—by now the situation has become so desperate that management is likely relieved that it has that kind of life insurance in place.

It might actually need it.

By Graham Warwick

Follow Managing Editor-Technology Graham Warwick on Twitter **@TheWoracle**

warwick@aviationweek.com

COMMENTARY

Turbine Tussle

Does a 20,000-engine market await the winner of the U.S. Army's ITEP contest?

Remember the last time the U.S. Army had a competition for an aircraft engine that was new from its centerline out? It was 1985, for the T800 to power the Boeing Sikorsky RAH-66 Comanche—and that did not end well.

Before that it was 1971, when General Electric won the T700 program to power the Utility Tactical Transport Aircraft System, which became Sikorsky's UH-60 Black Hawk. The T700 was also picked by both finalists for the Advanced Attack Helicopter, which became the Boeing AH-64 Apache—and the rest is history.

U.S. ARMY

Now the Army has launched a new-centerline competition, the Improved Turbine Engine Program (ITEP) for a 3,000-shp-class turboshaft. It is billed as the Pentagon's largest engine program (in numbers)—the Army plans to buy 6,215 beginning in 2024 to reengine AH-64Es, UH-60Ms and medevac HH-60Ms.

But the true scale could be much larger. GE will deliver its 20,000th example in November and, as the T700 and CT7 commercial turboshaft and turboprop, it powers 25 rotary- and fixed-wing platforms. ITEP could reengine U.S. Air Force HH-60Ms and Navy MH-60s, other T700/CT7-equipped aircraft and power some of the Future Vertical Lift rotorcraft planned to replace the Pentagon's helicopter fleets.

The T700 was the product of a process similar to that expected to result in ITEP, but over a much shorter timescale. GE and Pratt & Whitney were awarded contracts in 1967 to demonstrate 1,500-shp engines. The GE12 ran in 1969 and was selected over Pratt's ST9 and Lycoming's PLT27 in 1971. The first T700 ran in 1973, the Black Hawk flew in 1974 and the Apache in 1975. The engine entered service in 1979.

Pratt, now teamed with Lycoming, tried again in the competition to power the Comanche, but along with a GE/Williams bid, lost to the Light Helicopter Turbine Engine Co. team of Allison and AlliedSignal—now Rolls-Royce and Honeywell. The RAH-66 was canceled in 2004, but its engine continues in production as the commercial CTS800.

As a result, Pratt & Whitney has not participated in the rotorcraft market except through its Canadian sister company. This makes ITEP, for which it is teamed with Honeywell under the Advanced Turbine Engine Co. (ATEC), crucial for Pratt. Competition will come from GE, although the Army anticipates other bidders. Rolls says it will not bid. France's Turbomeca has no comment.

In preparation for ITEP, under the Army's Advanced Affordable Turbine Engine (AATE) program, GE and ATEC received contracts in 2008 to demonstrate 3,000-shp engines providing 50% more power at 25% lower specific fuel consumption than the T700. Both the GE3000 and ATEC's HPW3000 ground-demo engines ran in 2013, and AATE was completed in 2014.

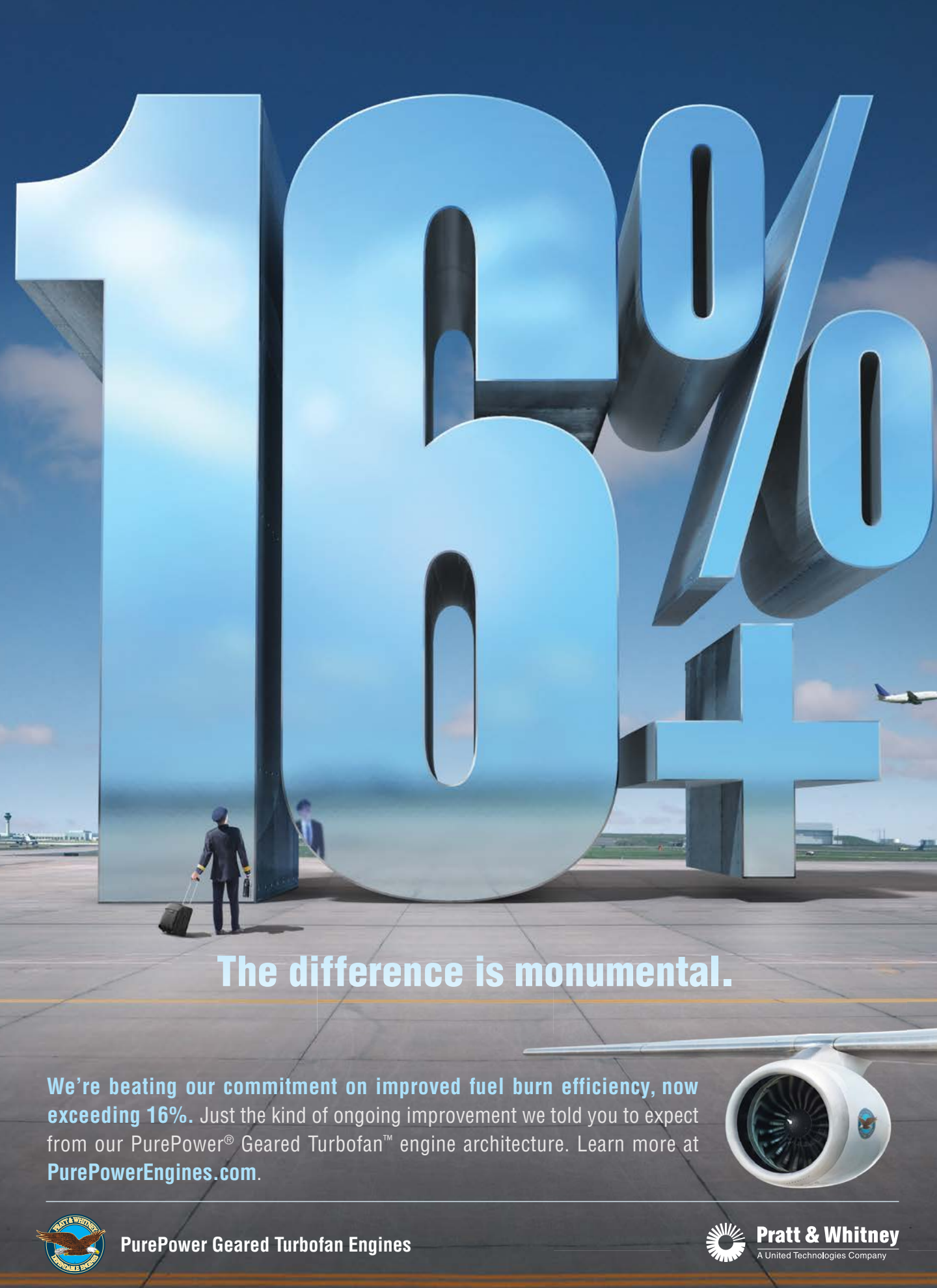
The request for proposals (RFP) for a two-year ITEP preliminary design phase was finally released on Sept. 24. Contract award is planned by summer 2016. The Army has funding to take two engines to preliminary design review, then plans to downselect to one in fiscal 2018 for engineering and manufacturing development.

The first engine to test is scheduled for 2021. Low-rate initial production is to begin in the third quarter of fiscal 2024 but, as the Army will field reengined Apaches and Back Hawks together in Combined Aviation Brigades, initial operational capability is not anticipated until 2027—almost 20 years after AATE began.

This is in marked contrast to the speed with which the T700 was developed and fielded, but it is due to the technology challenges in ITEP, the Army maintains. The AATE program was necessary to prove the power and efficiency goals could be achieved, reliably and affordably, within the T700's volume, and was successful, says Lt. Col. Curt Kuetemeyer, Army ITEP product manager.

The program's key performance parameters are not the same as AATE's goals, but similar, he says. The RFP sets a threshold maximum power of 1,850 shp at 6,000 ft. density altitude on a 95F day, with an objective of at least 2,050 shp. The dry weight objective of no more than 465 lb., as with the power goal, includes inlet particle separator. ITEP will increase the range, time on objective and hot-and-high performance of the UH-60 and AH-64.

To meet the challenge required a dual-spool engine, with dual centrifugal compressors, says ATEC. GE's is a simpler single-spool engine, likely with an axial-centrifugal compressor layout similar to the T700's. In what will be a fierce competition, GE says it will apply compressor, ceramic matrix composites and turbine technology from its demonstrator for the Army's later 5,000-10,000-shp Future Affordable Turbine Engine to its ITEP proposal "where sensible."



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COMMENTARY

Eyes Wide Shut

Air Force seeks ways to measure value of UAV video

U.S. AIR FORCE

By Bill Sweetman

Read Sweetman's posts on our blog **Ares**, *updated daily:*
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Whoever said, "Half the money I spend on advertising is wasted; the trouble is I don't know which half" never thought the principle could apply to intelligence, surveillance and reconnaissance (ISR). But 20 years after the first use of the General Atomics-Airborne Systems Inc. Predator UAV, that disastrous scenario is close to reality.

The root of the problem is what U.S. Air Force deputy chief of staff for ISR Lt. Gen. Robert Otto calls the "virtually insatiable" appetite of U.S. Central Command (Centcom). At a media gathering this month, Otto cited two statistics: In 2005-06, the Air Force could support five 24-hr. ISR combat air patrols (CAP), which met half of Centcom's demands for ISR as a whole. Today it provides 60 CAPs and meets 20% of what Centcom wants. Centcom's stated needs have grown thirtyfold.

In 2009, when then-Defense Secretary Robert Gates fired the Air Force's top military and civilian leaders, their insufficient enthusiasm for UAV operations was high on the charge sheet. That has not encouraged the service to resist Centcom's demands. The cost has been considerable. Each CAP takes nine people—a pilot, sensor operator and mission intelligence specialist for each 8-hr. shift—to operate the UAV, plus launch and recovery pilots and maintainers in-theater.

And that's only the start, because when ground commanders say "ISR," they almost invariably mean full-motion video (FMV). That product eats a lot of mobile communications bandwidth, whether Air Force-owned or rented from civilian suppliers. Its "soda-straw" field of view has to be placed in context on the ground. Processing and analyzing FMV—discriminating between farm tools and weapons, identifying behavior patterns such as bomb-planting—to generate actionable intelligence is manpower-intensive, stressing and resistant to automation. In its Air Force Distributed Common Ground System centers (see photo), the service is seeing "stress levels similar to remotely piloted aircraft pilots," Otto says.

And before any boot-centric warfare types start snarking about the hardships of life in an air-conditioned trailer in Nevada, that is a real, strategic issue. It gets tougher as fighting expands in Syria and Iraq, where there is little that is reliable in the way of human intelligence or ground observers, where ISR leads the fight, and rules of engagement are rightly strict. "Are we killing more terrorists than we're making?" is the standard measure, Otto says.

The cost extends beyond the immediate picture. Most of the U.S. ISR armada is of little use if the adversary (or an ally) has fighters or any ground-based air defense system more capable than a shoulder-fired missile. There are a few stealthy Lockheed Martin RQ-170s and secret Northrop Grumman RQ-180s, but their use likely is shared with the intelligence community, which guards them jealously as "sources and methods." But as the Air Force strives to feed Centcom's appetite, there is no money for a new UAV that would be more like an MQ-9 Reaper in cost and performance, with an adequate level of all-aspect, broadband stealth, but that can lose a platform without losing the crown jewels of stealth.

That is not the worst of it, however. "My sense is that there is a pattern of diminishing returns," Otto says, as terabytes become petabytes. "What is the added benefit of more coverage? Right now, I'd have a hard time telling you."

Behind that problem is a simple but yawning gap. "We haven't figured out a measure of effectiveness," Otto says. "You say you've looked at 450,000 hr. of FMV. So what? How many [improvised explosive devices] did you find? How many bad guys did you take off the battlefield, and were they low-level or Osama bin Ladens?"

Absent such a measure, the risk—maybe the reality—is that the number of CAPs and the hours of FMV becomes the ISR equivalent of a Vietnam War body count.

The lack of a good metric hampers the most straightforward of comparisons or measures to improve efficiency. Where is a Reaper the right tool, and where would a manned airplane—a Textron Beech MC-12 or Pilatus U-28—work better? Is wide-area electro-optical surveillance, FMV or radar the best sensor in a given environment? Today, it is hard to tell. Some commanders demand full analysis of high-altitude imagery even when change-detection technology shows no evidence of activity. Not doing that—"activity-based intelligence," Otto calls it—could improve the efficiency of analysis by 10-20%.

Otto has tasked a team, which is expected to be working well into 2016, to develop some measurement tools and standards, but he can expect a tough time selling it to FMV-addicted commanders. And if they in turn attempt to depict it as the blue-suiters trying to sell out the boots-on-the-ground-warfighter community, which is quite likely, they will need to be called on it.

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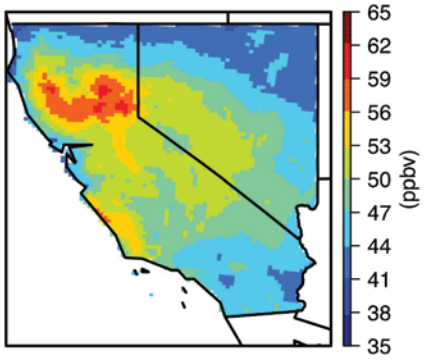
COMMENTARY

Tracking Pollution

International satellite data can pinpoint sources of surface ozone

Ozone pollution is a recognized health threat, implicated in respiratory problems ranging from asthma to lung cancer. What to do about it is another story.



NASA/JPL-CALTECH/GEORGE MASON UNIVERSITY

The U.S. Environmental Protection Agency (EPA) has lowered the permissible level of ground-level ozone from 75 to 70 parts per billion (ppb), hoping to offset industry costs in cleaning up auto and industrial emissions that form ozone when exposed to sunlight, with public-health benefits estimated as high as $5.9 billion.

California is sure to feel a particularly keen impact from the new regulation. Ozone is a key component in the smog long blamed on the state's combination of traffic, sunny weather and topography, which traps it in urban valleys. But there are other sources of ozone that elude local efforts at control, and those are particularly severe in California and neighboring states.

Wildfires, which have been severe during the ongoing drought, pump ozone into the atmosphere. So does the booming Asian economy, which inadvertently exports ozone along with low-cost manufactured goods. The first stop for a lot of that ozone is California and its neighbors, where distinguishing ozone that can be mitigated from "background" ozone that cannot is becoming more important.

"Based on scientific studies that say that long-term human exposure to ozone is bad for our health, that is the reason the standards are dropping," says Kevin Bowman of the Jet Propulsion Laboratory in Pasadena, California, principal investigator for the Tropospheric Emission Spectrometer (TES) instrument on NASA's Aura Earth-observing satellite. "But as the standards drop, the relative importance of background ozone has to go up. When we were generating 100 ppb of ozone, regularly, in the '70s, that background ozone wasn't a big deal."

Bowman and a team of atmospheric scientists have used data from TES and another instrument on the Aura spacecraft—the Ozone Monitoring Instrument (OMI)—to sort out the various ozone sources. In Northern California and Nevada, they found background ozone accounted for 48.3 ppb of the total ozone load there, or 77% (see map). That added an average of 2.4 ppb to previous estimates of background ozone, which could make a difference as the EPA tightens its standards.

"Our study improves calculations of total and background ozone levels from both nonlocal ozone and wildfires, data that may prove useful to policymakers," says Min Huang of George Mason University in Fairfax, Virginia, who led the satellite study while doing postdoctorate work at JPL. "Our method can potentially be applied broadly to predict air quality in other time periods and locations."

The NASA-backed JPL study used Aura data from the summer of 2008, making it nonoperational. However, Bowman says, "If there was sustained interest and the federal government was interested in providing that capability, it certainly could be turned into an operational capability."

While the TES and OMI instruments used in the study could segregate background and human-generated ozone, new instruments in development could generate the same sort of information with even higher fidelity, Bowman says. Of particular interest in the U.S. is the Tropospheric Emissions: Monitoring of Pollution (Tempo) instrument being designed to measure atmospheric pollution over most of North America from a hosted-payload perch on a commercial communications satellite in an appropriate geostationary orbital slot.

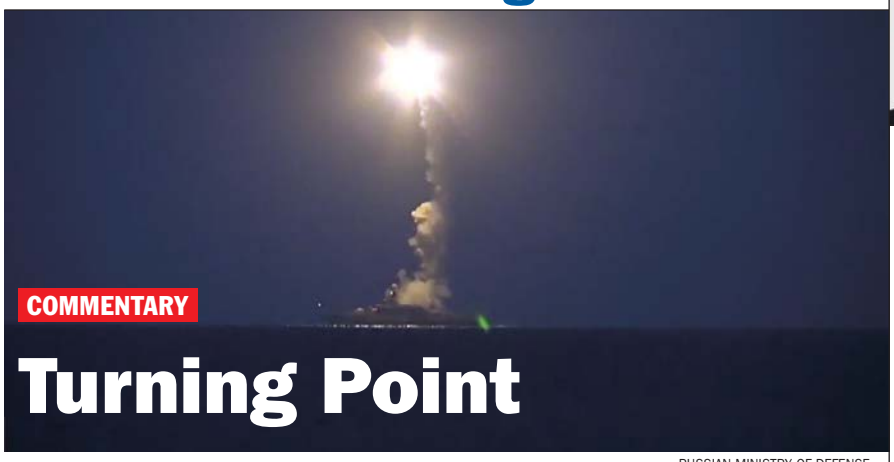
To track ozone across borders, Bowman and his colleagues are working on an international constellation of geostationary and orbiting spacecraft equipped with instruments that can detect near-surface ozone by combining thermal infrared and ultraviolet wavelengths in their spectroscopy, as was done with the study using Aura data, for other portions of the spectrum.

Among potential components of an air quality composition constellation of geostationary and low Earth polar-orbiting spacecraft are Tempo; the Sentinel 4 and Sentinel 5 precursor hosted payloads for Europe's Copernicus Earth-observation initiative, and the Geostationary Environment Monitoring Spectrometer that Ball Aerospace is building for the (South) Korea Aerospace Research Institute's GEO-Kompsat-2B spacecraft set for launch in 2018.

"This constellation would provide the kind of information necessary to accurately estimate the global sources of local pollution," says Bowman.

In the U.S., funding for space-based Earth-science projects such as Tempo that can help regulators monitor dangerous air pollution has gotten tangled up in an effort by a small but powerful group in the House of Representatives to cut work on climate change.

Just as today's ozone-monitoring capability from space usually doesn't discriminate between sources of pollution for the purpose of regulation, some U.S. lawmakers have failed to distinguish between space science that doesn't meet their ideological bent and that which could add more precision to pollution control.



COMMENTARY

Turning Point

RUSSIAN MINISTRY OF DEFENSE

Russian cruise missile launch changes post-Cold War equation

Russian cruise missile strikes launched from the Caspian Sea into Syrian territory mark an end to a 25-year advantage the U.S. has had in terms of precision weapons, according to retired Gen. Jack Keane, the former Army vice chief of staff. "The Russians have had this capability, and they're obviously using it," Keane, now chairman of the Institute for the Study of War, said during an Oct. 8 Senate Armed Services Committee hearing. "This technological advantage that we have had is gone," he said, adding that Russia, China and Iran have caught up.

In addition to a waning technological advantage, Ambassador Stephen Sestanovich, ambassador-at-large for the former Soviet Union 1997-2001, says the change signified by Russia's involvement in Syria's civil war is a political shift. In the Cold War, Soviet officials feared military escalation. Since the end of the Cold War, the U.S. has used its military without fear of Russian interference. "Putin changed that. He said, 'You cannot act independently anymore without worrying about my actions.'"

THE PENALTY BOX

A Chicago-based aerial imaging company specializing in photography of vacant properties has been hit with potentially the biggest fine yet for operating commercial unmanned aircraft recklessly and endangering airspace safety. The FAA has proposed a $1.9 million civil penalty against SkyPan International for conducting 65 UAS flights March 2012-December 2014 in congested airspace over New York and Chicago. Of those, 43 were in tightly restricted New York airspace that neighbors airports.

"These operations were illegal and not without risk," says the FAA. The unauthorized operations cited all predate an exemption SkyPan obtained from the FAA to enable limited, low-risk, commercial small UAS operations. The agency has granted almost 1,750 exemptions so far. Under its exemption—which was not in effect when the unauthorized flights were conducted—SkyPan needs a letter of agreement with the airport or a certificate of authorization from the FAA to fly within 5 mi. of an airport. Operations must be over private or controlled-access property, below 500 ft., and at least 500 ft. away from nonparticipating persons. SkyPan has 30 days to respond to the proposed penalty and can appeal or negotiate the fine, according to the FAA.

IMPOSING FINES

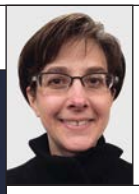
Congress passed the fiscal 2016 defense authorization bill to set policy for the Pentagon and forwarded it to President Barack Obama, who has pledged to veto it. The Senate passed the bill on a 70-27 vote. It would take a supermajority vote in both chambers to override the veto; 67 votes in the Senate and 290 in the House.

But if the veto forces a rewritten bill, Frank Kendall, the Pentagon's acquisition chief, believes many of the provisions—including the acquisition reform measures—will remain. That includes a provision penalizing military departments 3% of the total amount of its cost overruns during a fiscal year. The amount would be shifted to a fund for rapid prototypes.

If the provision, which Kendall says would not take effect until 2017, were in place now, two of the three military services would not face any penalty, but one would have to pay $24 million, he said at a Defense One conference on acquisition policy. Kendall adds that he is trying to figure out how to legally comply with the provision. "I understand the intent," he says. "I'm not sure from a practical standpoint whether it would be effective."

HURRY-UP HABITAT

The next big piece of human-rated hardware for NASA's "Journey to Mars" is a modular habitat that could be stationed near the Moon and visited by early Orion crew capsule missions, beginning as early as the first manned Orion flight. The official date of that mission has moved from 2021 to 2023, which could give NASA time to build a rudimentary hab module to go with it. "We want to take it on a shakedown cruise and put it around the Moon," says Associate Administrator Robert Lightfoot. Commercial companies could help. Bigelow Aerospace is set to attach a subscale-version expandable habitation module to the International Space Station (ISS) for testing later this year, and other companies are working under small NASA contracts on more traditional structures (*AW&ST*, April 27-May 10, p. 32). "While the exact mass and volume available for co-manifested payloads have not yet been determined, payloads about the same length, twice the width, and one-third the mass of a school bus could be launched to cislunar space with Orion," says the agency in a new report drafted to answer congressional demands for more detail on its human-exploration plans.



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Against All Odds

Bombardier's C Series is nearing certification, but will the program survive?

Jens Flottau Frankfurt

At this year's Paris Air Show, all eyes were on the C Series. Bombardier had finally brought over two test aircraft, and most who had toured the aircraft were full of praise for the cabin. Even Airbus CEO Fabrice Bregier and COO John Leahy were allowed inside. But what looked like a courtesy among colleagues has taken on a different connotation in hindsight: It may have been a sales pitch.

It was a sales pitch that ultimately failed, as made known to the aerospace industry Oct. 6, when both Airbus and Bombardier confirmed they had been talking about "business opportunities" and that those discussions had ended unsuccessfully. In June, Leahy remarked that Bombardier had built a "nice little airplane." But it obviously was not nice enough for Airbus to invest in the struggling program. In the wake of the talks' collapse, there is increasing concern in the industry as to whether there is a future for what Bombardier has planned as its main commercial aircraft program.

"Since Bombardier lacks the resources to make the C Series a commercial success on its own and since

A C Series test aircraft on the ground this summer. Bombardier is scrambling for access to fresh funds to finance certification and production ramp-up.

BOMBARDIER

we can't foresee a partner, Teal Group expects the program to be canceled," writes Richard Aboulafia, that firm's vice president-analysis. "The very fact that Bombardier was talking to Airbus implies they badly needed to talk with someone and that there was no one else. This does not look good at all." Kevin Michaels, vice president at ICF SH&E, believes "the odds [of cancellation] have gone up considerably" but still sees other options that may save the program.

"While [cancellation] has been discussed as an outside consideration in the past, we think it is now a far more realistic possibility," Credit Suisse writes in a note to clients.

Canadian newspaper *The Globe and Mail* cited an anonymous source as saying a deal was still possible and Bombardier was still open to further talks with Airbus. While that may or may not be true, the much more important question is whether Airbus would be prepared to reopen the case at some point. And the odds are it will not be.

Bombardier says it "will continue to explore initiatives such as a potential participation in industry consolidation." Neither Bombardier nor Airbus confirmed the talks have been about the C Series, but industry sources suggest Bombardier offered a major stake in the program to its rival.

The C Series, now in flight tests, is about $2 billion over budget. Following a series of delays totaling two years, the first aircraft is due to be delivered to Swiss International Air Lines in the first half of 2016. There are now 243 firm orders for the two versions of the aircraft.

Three issues need to be taken into consideration by any potential investor: the amount of money needed to finish flight tests and certification and for ramping up production to a realistic and sustainable level, which Michaels estimates to be around 60 aircraft per year; the conditions the Canadian government might impose on any partner and the kind of aid available; finally and probably most important, is the C Series market really big enough?

Aboulafia argues $3-6 billion is needed for the program to become a success. Scotiabank states in a research note that it expects Bombardier will need access to fresh cash by the middle of 2016. Credit Suisse believes the remaining cash burn until C Series production is in full swing could be up to $2 billion in the next 2-3 years. The company spent more than $800 million in the second quarter alone. As Credit Suisse estimates cancellation costs to be well under $1 billion, "potential savings appear significant enough to warrant serious consideration at this point," it writes.

Whatever the sum eventually is, a large cash injection appears to be needed. Michaels points out any partner would have to be "one with a strong balance sheet." He also believes "they can't go back to the capital markets."

The company is understood to have contacted other potential investors in recent weeks, among them Boeing and Comac. For different reasons, neither has shown any interest in the program. Following a refinancing round earlier this year, Bombardier has indicated it will partly float Bombardier Transportation, its rail unit, later this year.

Chinese investment in the C Series has long been a subject of speculation, and the possibility cannot be entirely ruled out, especially since Avic builds much of the structure. But considerable obstacles stand in the way of either Avic or Comac taking over the program.

Avic would no doubt love to own the C Series. For a vast state enterprise with 400,000 employees, the forthcoming MA700 78-seat turboprop is an embarrassingly modest flagship commercial product. But the central government would not allow an Avic purchase of the C Series program, because that would be an intrusion on Comac's turf. Comac, in turn, is supposed to spend state funds on developing a Chinese aircraft, not buying a foreign one.

Selling a majority stake in the C Series may also be easier said than politically achieved. An industry source says job guarantees demanded by Canada from Airbus may have been a negative factor. And while the Quebec provincial government has made clear it would be prepared to bail out Bombardier in one form or another, the challenge would be to do so in a WTO-compliant manner. General elections in Canada could also influence any decisions.

There is strong concern, particularly in Bombardier's supply chain, that even if the manufacturer manages to finance the ramp-up it will not be able to get the anticipated number of orders, because the aircraft's market is smaller than planned for. "A key problem for the C Series has been that carrier preferences have shifted toward larger narrowbodies, with orders for new-generation aircraft above 150 seats coming in over 10 times ahead of those for aircraft in the 100-150 seat range," J.P. Morgan writes in an extensive C Series analysis. "We have been surprised by the lack of demand for smaller narrowbodies and preferences could shift in the future. The issue for Bombardier is whether this will happen fast enough to shore up confidence in the C Series or whether the order surge for the reengined A320 and [Boeing] 737 has crowded out demand for other capacity for the next several years."

Not to forget: there is a lot of cheap secondhand capacity coming in as earlier long-term lease contracts expire.

—With Bradley Perrett in Beijing

Check 6 *What now for the C Series? Aviation Week editors discuss Bombardier's woes at:* **AviationWeek.com/podcast**

Risky Options

With fuel prices low, airlines have more choices between used and latest-technology aircraft

Jens Flottau Prague

For airline fleet planners, the next few years may look like heaven on Earth. A series of latest-technology aircraft will arrive, promising much lower operating costs. At the same time, the dramatic fall in fuel prices is making existing fleets viable again, creating options not on the table before. But there are risks involved for many parties, including manufacturers, lessors and airlines.

The industry has rarely seen such an influx of new aircraft models in a short period of time: the Boeing 787 and Airbus A350 will soon be followed by the A320neo and Bombardier C Series; then will come the 737 MAX, Mitsubishi Regional Jet and Embraer E2; the 777X is also slated to enter service at the end of the decade. That list does not include Russia's MC-21 and the Comac C919, which are not expected to play a significant role in export markets for the foreseeable future. Those developments were driven by the need for more efficient aircraft when fuel prices were twice what they are today, or higher.

Just as the fleet of new-technology aircraft is beginning to grow, led for now by the 787 and A350, another factor is kicking in: An increasing number of leasing contracts for midlife Boeing 777s and Airbus A330s, in particular, expire over the next few years. Lessors need to find new homes for dozens of used widebody aircraft per year. And while it would have been extremely tough to place the types in a high fuel price environment, airlines are beginning to change their minds about their use.

"We are currently looking at some things we would not have considered a few years ago," Alan Leeks, head of strategic fleet planning at Virgin Atlantic, said at the Istat Europe conference in Prague. "Used 777-300ERs at reduced lease rates are looking quite attractive," he added. Virgin envisions the Airbus A350-1000 as the frontrunner for the large twin long-haul segment, but may still opt to go for secondhand aircraft. "It is all a function of the fuel price and where you think it is going," Leeks says.

Virgin still operates a fleet of 11 A340-600s and the same number of Boeing 747-400s alongside 10 A330-300s and a growing fleet of 787-9s. The A340-600s and 747-400s are next in the replacement cycle even though the recent drop in fuel prices has made them more economical to operate, too.

Lower lease rates would have to compensate for the higher fuel burn compared to later-generation large twins such as the A350-1000, Leeks points out. Also, reconfiguring a 777-300ER with a Virgin Atlantic cabin would cost more than $20 million per aircraft. For a deal to be attractive to the airline, monthly lease rates for a 777-300ER would have to be less than $400,000, he says. According to Randy Tinseth, Boeing Commercial Airplanes vice president of marketing, 10-15 777s per year will come off lease in the coming years, including -300ERs.

Tough choices have to be made not only in the widebody aircraft market. "For some operators, A320 [current engine option aircraft] are now more economical than NEOs, particularly on shorter routes," says Jens Dunker, senior vice president-aircraft trading and global at China Aircraft Leasing Co.

The confluence of the arrival of new-technology aircraft, low fuel prices and increasing availability of used aircraft could spur further concerns over capacity increases far beyond what demand warrants. Airlines could be tempted to fall back into old habits of trying to gain market share based on relatively cheap capacity. If that turns into an industry trend, there are bound to be more unwelcome yield declines. While many airlines in Europe and North America have lately been reporting somewhat favorable yield trends, currency fluctuations—most prominently the significant appreciation of the U.S. dollar—have been a key factor in that development. But, given anticipated global GDP growth far below the current increase in international air traffic, analysts have voiced concern that airlines are expanding faster than they should, taking into account macroeconomic fundamentals.

"A lot of airplanes are entering the market at the same time," says Jeff Knittel, president of CIT Transportation and International Finance. While the amount of capacity coming in the form of 787s, A350s and later 777Xs is well-defined by order backlogs that no one expects to falter, the extent to which older aircraft are retained longer will define where capacity is going. "That will be the lever," Knittel says.

Robert Agnew, president and CEO of Morten Beyer & Agnew (MBA),

DUBAI AIRPORTS

A large number of Boeing 777s, including some from Emirates, will be available on the secondhand market soon.

points out that some shift in aircraft retirement trends can already be observed. While MBA data suggest aircraft were being retired after about 23 years when fuel prices were at record levels, that downward trend has been stopped and slowly reversed. Leases are being extended in more cases and even older 777-200ERs or A330s have better prospects of finding new roles with second-tier airlines aiming at market share gains.

The future of the in-service fleet and pace of retirements is of less immediate concern to manufacturers, but Airbus and Boeing have a strong interest in keeping production running for the A330 and 777, respectively. While a preliminary order for 75 A330s from China goes a long way toward helping Airbus bridge the gap between the A330 and the A330neo, Boeing has a longer road ahead. "At the current production rate, there is a 24-month gap between the current 777 and the X," Agnew says. "Boeing will have to manage that either through price or reduced production."

The lessor community has generally become more bullish about trading prospects for current-technology aircraft. "You can see value in both the current and new offerings," says Marlin Dailey, chief commercial officer of AWAS. "Last-off-the-line aircraft will have a very long and prosperous economic life."

When it comes to leasing used aircraft to new operators, more than fuel costs are at play. On top of the cabin conversion cost, challenges include the transferability of engine maintenance programs. Leeks emphasizes that with total care packages now commonplace, engine return conditions should be removed from leasing contracts, as they force airlines to perform unnecessary maintenance work.

Change Management

Scientists argue that aviation needs to be more aggressive to meet its own emissions targets

Jens Flottau **Geneva**

When the International Council on Clean Transportation stated that the air transport industry will miss future fuel-efficiency targets set by the International Civil Aviation Organization (ICAO), industry lobbying groups were immediately up in arms. But if experts gathered at the Air Transport Action Group's (ATAG) global sustainable aviation summit at the end of September are correct, they were right to sound the alarm.

The air transport industry has committed to improving fuel efficiency by 1.5% annually until 2020 and then freezing its total CO_2 output in 2020. The industry aims to halve emissions by 2050; 2005 will serve as the baseline. ICAO's separate target is for an annual fuel-efficiency improvement of 2%. While airlines are currently exceeding that target by a significant margin, some experts are concerned that the positive trend may not be sustainable for the longer term as various factors come into play and structural issues curb innovation.

The sector is also entering a crucial time as negotiations over the ICAO-backed global market-based measures (MBM) to regulate aviation emissions enter the decisive phase. A broad agreement about the set-up of such a system is the target of the next ICAO General Assembly in September 2016. The industry supports MBM as one of many initiatives to reduce carbon emissions because it has recognized that becoming more environmentally friendly is the only way to ensure further growth.

In addition to the MBM, ICAO plans to define a new model for aviation's CO_2 standard in 2016.

Airlines and manufacturers have been taking advantage of the low-hanging fruit for a long time, propelled by economic pressures to become more efficient. Aircraft cabins have become denser, particularly on short-haul routes. "Our quickest leverage is increasing utilization of aircraft, but we are doing this on the backs of the passengers," says Mirko Hornung, executive director for research and technology at Bauhaus Luftfahrt, a German aviation think tank. But, he adds, "How can we [best] transform energy consumption? We have to look at drop-in and nondrop-in solutions."

Average fuel burn will continue to be reduced as the Airbus A320neo and Boeing 737 MAX fleets are phased in over the coming years. On long-haul routes, the Boeing 787 and A350 are already recording reduced fuel burn. At some point, those effects will plateau, however, and more radical technological breakthroughs may be needed; biofuels are just one solution. Hornung is not the only one who doubts this can happen quickly enough.

"We have to be disruptive," Air New Zealand Chief Pilot David Morgan argues. "But conservatism will constrain development. I don't hold the view that radical measures will deliver toward the 2050 goals, largely because of the legacy thinking that persists in this industry." Morgan notes the slow transformation of air traffic control, along with economic and technological realities. "Aircraft last too long. They are renewed only in 20-25-year cycles because of the huge investment," he says. "The rate at which airlines replace aircraft is not the one we need for change."

While most agree that low fuel prices should not impede innovation per se, there are some incipient signs that airlines are opting to keep aging aircraft in service longer than they would if fuel costs were higher. If this trend persists, it will be much harder for the industry to sustain efficiency improvements.

Morgan says more fundamental questions need to be asked: "Are we too conservative in our approach to risk? And should we think differently about commercial risk?" He has some proposals for how his own profession should evolve. "Pilots should probably not be doing landings in 20-30 years. Half of the aircraft could fly autonomously or controlled by a system operator from the ground," he says. "That is the way forward."

Probably the single most important

Political challenges to achieving agreement on regulating aviation emissions center mainly on distinguishing between the obligations the developed and developing worlds respectively will shoulder.

STIRLING DAY

lever that could bring aviation nearer to its emissions targets is the introduction of biofuel on an industrial scale. "It feels slow, but amazing progress has been made," says Jennifer Holmgren, CEO of Lanzatech, a company that specializes in converting carbon-rich waste into fuel. "Back in 2006, nobody thought alternative fuels would take off. Now we are at 2,000 flights." The key unmet challenge is to "commercialize new technology," she says. "The problem is money and it is very, very risky."

In order to achieve scale, Holmgren says future alternative-fuel standards need to be technology-neutral. "We can't exclude those that have not been there from Day One," she says.

Will there be flights flown fully on biofuels within the next five years? "Yes," says Julie Felgar, Boeing's managing director of environmental strategy and integration. "But they will not be commercial flights."

As technology advances are being prepared, so is a regulatory framework to prod airlines into becoming more environmentally responsible. The technical details of ICAO's global market-based measures are becoming more well-defined, but additional policy guidance is needed, according to Paul Steele, senior vice president/member/external relations at the International Air Transport Association (IATA).

"We need policy decisions to advance the technical work, but states do not seem to be there yet," Steele says. In his view, technical work alone is no longer a reason for great concern. However, he recommends that government step up now to advance the process, even on the technical side.

ICAO in 2013 decided to set up its market-based measures to come into effect by 2020; a fundamental agreement on how it will work is set to be reached at the next assembly, which will take place in Montreal in September 2016. Talks are progressing, but the time pressure is substantial, as the ICAO Council is scheduled to present its recommendation to the member states in June. Because of this, most of the planning and basic negotiations must be completed by April or May.

"There are still many red lines in different parts of the world," says Victor Manuel Aguado, who represents Spain on the ICAO Council. "We need to move into negotiations," urges Laurence Graff, head of the European Commission's international carbon market unit.

The political challenges to be resolved center mainly on distribution and distinguishing between the obligations that the developed and developing worlds need to shoulder. "It is a hard thing," says Carl Burleson, FAA deputy assistant administrator of policy, international affairs and environment. "I expect some drama at various points."

The key issue to be resolved in the upcoming negotiations is "the right level of differentiation," IATA's Steele points out. While the concept as such is not in doubt, he raises the question of how long it should be in place. "It cannot be locked in for 20 years with no chance to change," because the distribution of economic power evolves, he notes. The industry's position is to have as little differentiation as possible to avoid market and competitive distortions.

Burleson argues that the United Nations Climate Change Conference in Paris, which will start on Nov. 30, could possibly provide a valuable push for aviation. If a far-reaching agreement on climate-change measures is signed, it will free up states to make environmental decisions for all sectors and not be constrained by aviation-specific packages (the aerospace industry is responsible for around 1.5% of emissions).

ATAG Director General Michael Gill urges the industry to "stop thinking about [carbon-neutral growth] as a challenge but see it as an opportunity, too." The pending MBM needs to be "simple and robust," he emphasizes. "We are within touching distance of an agreement, and we have to stay on course."

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Grounded?

Government intervention in RD-180 supply hampers ULA's competitiveness, CEO says

Mexico's Morelos-3 communications satellite lifted off at 6:28 a.m. local time on an Atlas V from Cape Canaveral AFS, marking ULA's 100th successful mission.

ULA

Amy Butler Washington

For nearly 10 years, United Launch Alliance (ULA) was the monopoly rocket supplier to the U.S. government for national security launch missions, but now the tables have turned.

Only a year ago, rival SpaceX was crying foul that the Pentagon's procurement plans unfairly excluded it from bidding for work because the certification process for Falcon 9 was taking longer than expected. Now ULA is facing a somewhat similar situation; government intervention in its supply chain is forcing it to submit its bid—without an engine—in its first duel with SpaceX for a national security launch mission. Since that is the case, the company may have to get creative.

The U.S. Air Force issued its final request for proposals (RFP) Sept. 30 for a GPS III mission slated to launch in May 2018. This is the first of nine anticipated competitive launches in the service's "phase 1A" Evolved Expendable Launch Vehicle (EELV) program, during which SpaceX is allowed to compete for work with ULA. These launches up for grabs are separate from ULA's exclusive 36-core deal with the Air Force, which includes guaranteed work through 2019.

Proposals are due Nov. 16, and a winner is likely to be announced in March, Claire Leon, director of the Space and Missile Systems Center's Launch Enterprise Directorate, told reporters during an Oct. 2 press teleconference.

Criteria for the competition are fairly simple. In a pass/fail evaluation, each bidder must pass all four areas—orbital accuracy, mass to orbit, launch operations and plausible schedule—to compete. The Air Force will then select the winner based on lowest price. The contract will be fixed-price and require the winner to provide a full launch service, delivering the satellite through to insertion into orbit. Leon says the average EELV price to date is about $140 million; she expects the bid to undercut that standard considerably, although she declined to cite a range.

The RFP was written to allow ULA to invoke a waiver pending the outcome of negotiations in Congress about access to the company's Russian RD-180 engine. It powers the Atlas V, the only rocket ULA can offer to ensure a reasonable chance of winning, as the Delta IV is priced too high.

This is, in part, a conundrum of ULA's own making because of how the company obligated its rockets in its annual RD-180 order of 29 engines, last made in early 2015. In the fiscal 2015 National Defense Authorization Act, Congress limited the company to using only five of the 29 for military missions because they were the only ones paid for in full prior to the outbreak of hostilities when Moscow annexed Crimea. Congress drew a line to cut off access to the RD-180 in part to make a political statement against Russia but also to force a shift to a new, U.S.-sourced engine.

However, ULA CEO Tory Bruno says those five RD-180s are already allocated to civil and commercial missions, for customers he declines to identify. Another 15 are reserved for use in military missions already contracted under the company's 36-core-block buy with the Air Force. This leaves nine in question. "We had to use the five to keep the factory from gapping," Bruno says, adding that engines for an Atlas V are procured up to three years prior to a launch. The rocket itself takes about two years to move through the production process.

A House-Senate conference committee has proposed allowing ULA access to four more RD-180s for military missions. This would provide some relief—and an engine for the GPS III mission bid—but it is unlikely President Barack Obama will be able to sign the bill anytime soon. The government agreed to a continuing resolution—limiting spending to fiscal 2015 levels—through Dec. 11. This hampers the Pentagon's ability to conduct more competitions for the EELV program. And the White House has promised to veto the authorization bill if Congress persists in using wartime operations accounts to pay for items not directly related to actions abroad. It is unclear whether the government will continue through all of fiscal 2016 at 2015 levels, if a 2016 bill will get passed or, even worse, a government shutdown will occur over other fiscal disputes between the White House and right-wing Republicans.

"Four more [engines] is not nearly enough to get to 2019 first flight [of Vulcan] and through the certification flight process for Vulcan until 2021 or

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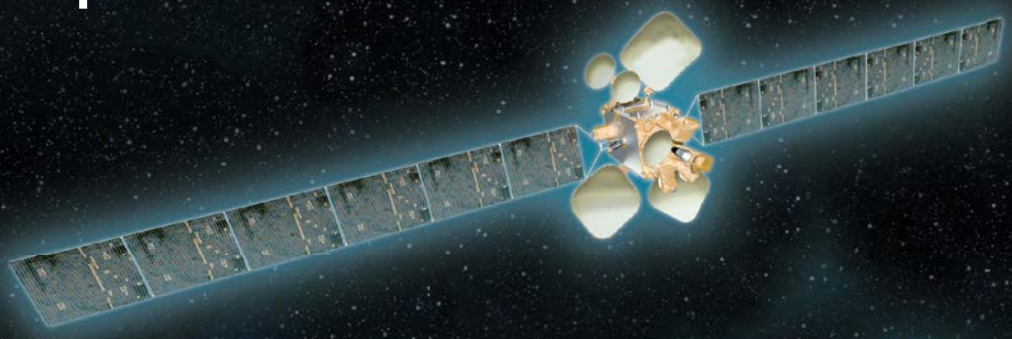

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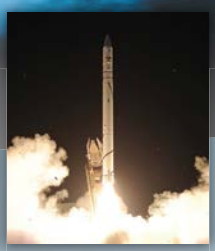

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2022. So there is still a pretty big gap," Bruno says. "At this moment . . . this year's bill isn't signed. . . . I don't have any engine" for the GPS III bid. "If I had to [bid] today, I would be unable to propose due to a lack of engines. If the bill gets signed and I have engines, it would be different conversation. "

Bruno is referencing the Vulcan, a developmental rocket slated to replace Delta IV and Atlas V in the next decade. Bruno says there is a market for up to 50 more Atlas V missions before Vulcan is operational.

Leon, however, says the RFP allows ULA to submit a bid with a waiver that assumes the RD-180 would be available. This is a short-term solution to keep the paperwork moving on the solicitation. At some point, an actual engine would be needed for ULA to proceed with its bid.

The five engines approved in the 2015 bill cannot be reallocated to military missions, according to a ULA spokeswoman, because once they are designated for a specific mission special requirements start to be addressed with hardware.

The Air Force had hoped to receive approval to use 18 RD-180s in the fiscal 2016 bill, Leon says. The 2015 law and 2016 bill both allow for the Pentagon to issue a waiver, pending review by the defense secretary and assurance that the engines are critical for national security. Thus far, the Pentagon has not said whether or when it would issue such a waiver. Leon notes, however, that if ULA requires an engine for the competition, it would help provide "ammunition" for the Air Force to argue for one.

Meanwhile, SpaceX is expected to propose using its upgraded Falcon 9 rocket, which incorporates a new engine. Leon says the Air Force could be as little as one month away from certifying it for national security launches. SpaceX is continuing work on a fix to its existing Falcon 9 to address the root cause of a June 28 mishap caused by a faulty strut in the second-stage liquid oxygen tank. SpaceX officials hope to fly again by year-end, and Leon says the Air Force would verify the new hardware for the system, but a full recertification is not needed.

ULA's 100th successful space-vehicle separation Oct. 2 with a commercial payload is a "symbolic" coincidence, says Bruno, who is focused on reducing the Atlas V price to be more competitive in the commercial market. Mexico's Morelos 3 satellite lifted off from Cape Canaveral AFS, on an Atlas V 421 rocket. Although sold to the Mexican government, the mission was procured via a commercial sale with Lockheed Martin's Commercial Launch Services (CLS), which markets the Atlas V commercially. By contrast, ULA—a joint venture between Boeing and Lockheed Martin—manages Atlas V and Delta IV U.S. government sales.

The bulk of ULA's work is still with the U.S. government. The Morelos 3 launch is only the 11th commercial sale of 100, but Bruno is eyeing more to compete with SpaceX. Firm details on a new sales plan for ULA and CLS commercial launches are still under wraps, but Bruno did allow a peek at a new "Fast Buy" initiative he hopes to roll out by year-end, in an Oct. 1 interview with Aviation Week.

"Fast Buy is a completely new way of buying a rocket and settling on the launch service and configuration you need," Bruno says. "We are going to be rolling out a system where the customer can come in and understand in advance the price of the launch service very quickly and understand exactly what rocket they want—almost do their own trades to a certain degree. And also then see fixed-price options they can add to that basic launch service [for things such as] insight into the processes or financial reporting. Those are all things they can trade themselves," Bruno says. ULA and CLS are also working on closer coordination, to remove any confusion about the process.

Bruno hopes a commercial customer can settle on its needs and sign a contract within a week; today, that takes 2-3 months. He intends to also correct misperceptions. "For commercial customers, especially, we have a reputation in that marketplace —not justifiably—of not being necessarily available. They sort of assume our manifest is completely full with Air Force missions, and if they were to find a slot on the manifest, they would have a risk of the Air Force dropping them out. . . . That has never happened [but] that myth exists."

Bruno is also trying to tackle ULA's high pricing. The company has released very few specifics on its launch costs, though Bruno cited an average of $164 million for Atlas V 401 in its 36-core-block buy with the Air Force. Those prices are locked in, but Bruno says sales outside the block buy could go far below that price.

Reduced pricing relies in large part on strategic partnerships with key suppliers who are willing to invest in long-term nonrecurring engineering work and sell at lower cost. These suppliers, along with ULA, are betting that the company will be able to transition from a government-funded monopoly into a nimble competitor. Though Vulcan is on the horizon, Bruno sees a market to sell up to 50 more Atlas Vs beyond what the government has included in its 36-core-block buy, which lasts until fiscal 2019.

"[Suppliers] are moving into that long future and they are saying, 'Yeah, we have confidence ULA is going to be here for the next 20 years'"

This shift is "made possible because of the long-term commitment between us and the suppliers to give them a higher volume of work, and they are committed [for] over a decade or more," says Bruno. "They [will] catch the post-block buy Atlas and Vulcan [work]. They are moving into that long future and they are saying, 'Yeah, we have confidence ULA is going to be here for the next 20 years.'"

Among the deals cited are a strategic partnership with composite structures manufacturer RUAG signed in July and another with Orbital ATK to supply solid rocket boosters for Atlas V and Vulcan, a shift from a previous arrangement with Aerojet. Although not committing to a specific reduction, Bruno says these types of partnerships will drop the cost of the Atlas V by a double-digit percentage. "I have not seen deals like this in my entire career," Bruno says.

Treading Carefully

Full-scale development of a Chinese and Russian 787-10 competitor looks imminent

Bradley Perrett **Kuala Lumpur**

Multinational management has emerged as a major risk in a Sino-Russian program to build a competitor to the Boeing 787-10 and Airbus A330-900. A further worry is the risk that, at some unpredictable time in the future, Russia's relations with the West will result in sanctions on the program, say industry sources familiar with its progress.

The airliner, for now dubbed the Long-Range Wide-Body Commercial Aircraft (Lrwbca), will need advanced systems from Western suppliers, especially engines from Rolls-Royce or General Electric. But potential providers are treading carefully.

China and Russia are likely to agree on the airliner project by the end of this year, says Yury Slyusar, president of United Aircraft Corp. (UAC), which will undertake the program jointly with Comac; the manufacturers are already doing preliminary work together. It is unclear whether the intergovernmental agreement will signify the launch of full-scale development. Even if it does not, a commitment to proceed should not be far away, because the first flight is scheduled for 2022 and entry into service in 2023-25.

Comac and UAC are undertaking the enterprise at the behest of their governments, which appear to have decided for entirely political reasons that China and Russia should cooperate in building a widebody airliner. Comac's managers, at least, would prefer to create such an aircraft alone, say industry officials, who nonetheless point out that the Chinese should benefit from the greater integration skills of Russian engineers.

The Chinese and Russian teams themselves need to be integrated, however. Coordination so far has been poor, say managers working on the project, noting that the need for harmonized decision-making and smooth communication will only become more challenging during full-scale development. Russian and Chinese aerospace engineers have experience in working with foreign counterparts, but not in 50:50 development and production of an airliner.

Because of such major issues, potential suppliers are unlikely to bet funds on the program in true risk-sharing contracts. They will either ask Comac and UAC to finance work on systems or, in what amounts to much the same thing, will ask for contractual rights to compensation if sales do not exceed set levels.

Comac and UAC have issued requests for information to prospective suppliers. The offers are very likely to be adaptations of current equipment. The thrust requirement of up to 75,000 lb. per engine suggests the use of a variant of the General Electric GEnx or the Rolls-Royce Trent 1000 or 7000, the turbofans installed on the 787 and A330-900. Integrating even a currently available engine on Lrwbca would cost hundreds of millions of dollars.

UAC's forthcoming MS-21 narrow-body airliner uses a Western engine, but getting one for the Lrwbca may not be so easy. "If, early in the MS-21

UAC

How the Proposed Sino-Russian Widebody Stacks Up

	UAC/Comac Long-Range Widebody Commercial Aircraft	Airbus A330-900	Airbus A350-900	Boeing 787-10
Seating				
Three-class configuration	258-280	287*	325*	323**
Two-class configuration	261-291	n.a.	n.a.	n.a.
One-class configuration	321-416	440	440	n.a.
Span (meters / ft.)	58-61 / 190-200	64 / 210	64.75 / 212	60.17 / 197
Length (meters / ft.)	57.5-63.43 / 189-208	63.7 / 209	66.8 / 219	68.27 / 224
Height (meters / ft.)	17.9 / 58.7	17.18 / 56.4	17.05 / 55.9	17 / 56
Fuselage				
Width (meters / ft.)	5.92 / 19.4	5.64 / 18.5	5.96 / 19.6	5.74 / 18.8
Height (meters / ft.)	6.07 / 19.9	n.a.	n.a.	n.a.
Cabin				
Max. width (meters / ft.)	5.61 / 18.4	5.26 / 17.3	5.61 / 18.4	5.49 / 18
Floor width	5.53	n.a.	n.a.	n.a.
Cruise speed (Mach)	0.85	0.82	0.85	0.85
Thrust per engine (lb.)	71,226-75,000	72,000	84,000	76,000
Range (km / nm)	12,000 / 6,480	12,130 / 6,550	14,350 / 7,750	11,910 / 6,430
Payload (metric tons)	48.83-50.4	n.a.	n.a.	n.a.
Fuel (metric tons)	103.7	111.2***	111.1***	101.1***
Gross weight (metric tons)	208.8-234	242	268	253

Notes: *Typical. **Unusually tight arrangement. ***At 0.8 kg/liter.

Sources: Airbus for A330, A350 and Boeing for 787

program, relations between Russia and the West had been as they are now, Pratt & Whitney would have had a much harder time getting permission to supply the PW1000 for that aircraft," says analyst Sash Tusa of London consultancy Agency Partners. "Now, if Russia began to interfere in the Baltic states, the U.S. and Britain would not hesitate to stop a GE or Rolls-Royce program to supply engines for the Russian and Chinese widebody."

In principle, the Lrwbca, launched 12 years later than the 787, should have the advantage of 12 years of technological advancement. But the use of improved but not entirely new systems will somewhat limit that advantage. Still, if the joint managers can successfully execute their program, they should have an aircraft that is more efficient than what will be, by the mid-2020s, a quite mature Boeing product.

UAC is to take the lead on structural and aerodynamic design while Comac concentrates on systems, says one industry source. Production is supposed to be shared evenly, but allocation of the fuselage to Comac and the wing and tail fin to UAC seems to give the Chinese side the most work. Other manufacturing responsibilities are not known.

The joint company's head office will be in Shanghai, but the main engineering center in Russia, says an industry source. Although all statements so far have suggested that costs will be borne equally, the relative fiscal strengths of the two governments raise the possibility that China will end up paying more—and, if so, will want a larger share of the engineering and production work. Also, more Lrwbcas are likely to be sold in China than in Russia,

Whale Watching

Airbus plans five Beluga XLs, possibly more, to transport aircraft sections and components

Jens Flottau Frankfurt

When Airbus launched the Beluga XL program late in 2014, the end of the original Beluga fleet seemed within reach. But with the proposed hike in single-aisle production rates and the already decided ramp-up of other programs, it is increasingly likely Airbus will operate two types of outsize cargo aircraft for the foreseeable future.

"We plan mixed fleet operations for a minimum of five years," says Bertrand George, head of the Beluga XL program. He adds that "we will adjust to our needs over time" and a decision about if and when the current Beluga fleet will be phased out is not expected before 2019.

That Airbus was going to operate a mixed fleet for some time was planned from the start and had a strong influence on the design of the A330-based Beluga XL. The aircraft is laid out so that it can use the same infrastructure that exists or is in the process of being introduced for the A300-based Beluga fleet. One of the main features has been retained—full horizontal cargo access that is achieved by lowering the cockpit below the main deck cargo floor level.

Airbus reached a first crucial milestone in the five-year development of the Beluga XL by freezing design at the aircraft level following selection of major suppliers. The aircraft is based on the A330-200F and will feature a 227-ton (450,000-lb.) maximum takeoff weight, 15 tons short of the heaviest A330 passenger version that has already entered service with Delta Air Lines and Scandinavian Airlines (SAS). At its maximum payload of 53 tons, the aircraft has a range of 2,200 nm. But weight is not the most crucial design criterion for the new aircraft; what Airbus needs more of is volume, particularly to fit A350 fuselage sections and wings into the cargo bay.

The design freeze at aircraft level is to be followed by the detailed design phase, which will essentially be completed by the end of 2016.

After a competition that involved all three A330 engine manufacturers (Rolls-Royce, General Electric and Pratt & Whitney), Airbus has selected the Rolls-Royce Trent 700 as the sole powerplant for the five Beluga XLs planned to be built. "The engine meets our needs of minimum change, it is robust and mature," says George. Airbus also signed a total-care package with Rolls-Royce for the new fleet. The upper fuselage is being developed and built by Deharde and P3 Voith Aerospace, the main cargo door and lower nose fuselage by Stelia Aerospace. Aernnova has been selected for the rear fuselage and the dorsal fin, while Aciturri will supply the horizontal tail plane (HTP) box extension and auxiliary fins.

Airbus plans to start conversion work on the first Beluga XL in early 2017. The lower part of the fuselage will be assembled as is usual on the regular A330 final assembly line, and the half-completed aircraft, which will already have its wings and gear attached, will move on its own wheels from the Clement Ader factory to Building L34 in Toulouse, which has housed structural testing for the A350 program. The conversion, which mainly includes the installation of the voluminous upper fuselage and the lower nose fuselage, will take about a year. The sole Beluga XL test aircraft is to make its first flight in the summer of 2018. That milestone will be followed by about one more year of flight tests.

The exact number of flight-test hours has not yet been defined. But Airbus has applied for a derivative type certificate, which should limit certification work and flight hours. George says he expects the aircraft to accumulate less than 1,000 hr. in testing.

The first Beluga XL will enter service in 2019, followed by the second unit in the same year. Three more are planned to be built, and Airbus aims to deliver one per year for the next three years to operating unit Airbus Transport International.

But these plans are subject to change, and hinge on the manufacturer's actual transport requirements five years from now. Airbus is studying raising single-aisle production from 50 aircraft per month—an output to be reached by early 2017—to 60 or more before 2020, due to the strong demand for the A320neo and long wait times for new orders. A decision is due be-

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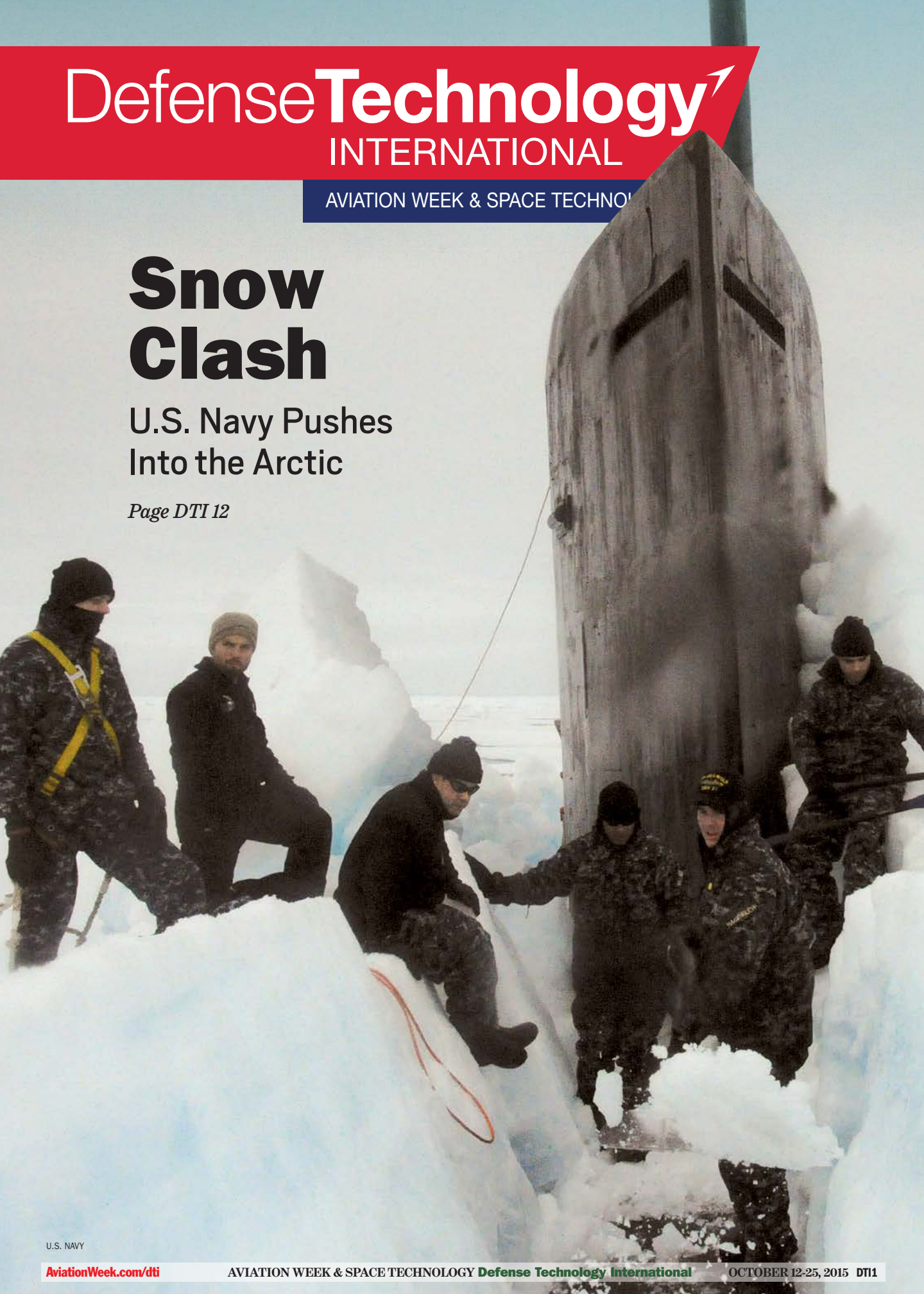

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Contents

The next issue of the *Defense Technology International* will be dated Nov. 9-22.

Cool Runnings

Turbofan bearing offers speed, fuel economy and improved engine performance

A recent development in Germany by FAG Aerospace and MTU Aero Engines could affect turbofan engine operations in three key areas: oil consumption, fuel economy and power generation.

The companies designed a mainshaft ball bearing that exceeds, reportedly for the first time, an operational speed parameter of 4 million mm/min. (160,000 in./min.)—66% greater than the 2.4 million mm/min. generated by most conventional bearings during takeoff.

At maximum speed, the bearing reportedly consumes the same amount of oil and generates identical temperatures as conventional bearings. At normal speed up to 50% less oil—6 liters/min. (1.6 gal./min.)—is needed for cooling, temperature is 25C (77F) lower and power loss drops as much as 25%.

Peter Glockner, head of product design at FAG Aerospace, attributes the reduction in oil consumption to, among other features, outer-ring cooling technology and an "integrated squeeze-film damper" that mitigates vibration load. The benefits of lower oil consumption and reduced vibration include power-loss savings, which "increase[s] the mechanical efficiency of the engine" and thus lowers fuel consumption, he adds.

FAG AEROSPACE

The high-speed ball bearing developed by FAG Aerospace and MTU Aero Engines for turbofan engines achieves a speed parameter in excess of 4 million mm/min.

The fuel savings are low: FAG Aerospace estimates the technology could save 200,000 tons of fuel annually for global turbofan fleets. In 2015, total fuel consumption for all aircraft is forecast to be up to 230 million metric tons.

Nevertheless, the technology appears to have clear engine-power advantages, and even miniscule savings add up for large operators, including the military.

For Glockner, the technology offers holistic engineering benefits. "The development of the bearing represents a major contribution to more efficient and reliable oil systems of future aircraft gas turbines," he says. "It is a step toward lower total weight, fuel burn and emissions, as well as improved reliability of next-generation aircraft engines."

The pitch diameter of the bearing is 168 mm. The inner and outer rings are fabricated of steel, and raceways are made of duplex-hardened high-temperature steel. The balls are made of silicon nitride ceramic, which reduces friction and lowers part weight 13% compared with conventional bearings.

Glockner says the bearing is probably most effective when installed on the high-pressure spool of an engine, but it can also be installed on intermediate- or low-pressure spools.

The bearing, which will be manufactured by FAG Aerospace and made available for all turbofan engines, is in precertification ground and flight testing.

The development took several years and emerged from a collaborative project funded by the German government's National Aviation Research Program.

—Pat Toensmeier

Reason and Rhimes

U.S. Navy proposes innovative approach to repulse cyberattacks on ships

There is probably no such thing as a networked device that cannot be hacked, including military systems—"even ships at sea," states the U.S. Office of Naval Research (ONR), in reporting about a new cybersecurity initiative.

ONR is developing the Resilient Hull, Mechanical and Electrical Security (Rhimes) system that is designed to keep shipboard mechatronics safe from cyberattack.

Hacking a ship's vital mechanical and electronic systems is a double-edged threat: Not only does it disrupt operations and possibly damage equipment, but an attack would make it difficult for a ship to fight effectively—or at all—if successful.

ONR reports that Rhimes is designed to prevent a cyberattack from disabling or, arguably worse, taking control of programmable logic controllers (PLC), the computers at the heart of many electromechanical processes.

Ryan Craven, a cybersecurity program officer at ONR, says Rhimes will protect shipboard electric power systems, hydraulics, steering and engine controls, damage-control systems, anchoring and climate control.

Rhimes will do this with a simple yet innovative technique described as "advanced cyberresiliency." Rather than using similar redundant backup systems that can be hacked as effectively as primary systems, Rhimes adds a "slightly different implementation for each [PLC's] program," Craven says in an announcement describing the project. In other words, no two PLCs will operate with exactly the same program. Multiple and different cyberattacks would thus need to take place to effectively take control of or disable shipboard equipment.

The outcome will ideally be the ongoing integrity and reliability of critical onboard systems. No date for implementation of Rhimes has been announced by ONR.

U.S. NAVY

Fire Controlman 1st Class Elizabeth Sharpe monitors a console on DDG 75 USS Donald Cook. The Office of Naval Research is developing Rhimes to protect electronic systems from cyberattack.

Meanwhile, U.S. Naval Sea Systems Command is presenting a cybersecurity industry day Oct. 30 at the Washington Navy Yard to inform industry of contracting opportunities in this field.

—Pat Toensmeier

Hot Shot

Australia commits to grenade launcher with multiple benefits

The Australian Defense Force will take initial deliveries of a new grenade launcher in the third quarter of 2016.

In late summer, the force ordered more than 200 40-mm MK47 lightweight automatic grenade launchers (AGL) from General Dynamics.

The MK47 replaces the MK19 Mod 3 AGL, also from General Dynamics, that entered service in 1968. The differences between them in portability, targeting and lethality are stark and demonstrate advances in the tripod- and vehicle-mounted weapon.

Greater use of composites and other lightweight materials means the MK47 weighs much less than the MK19—36 lb. compared with 77.6 lb.

The new weapon is compact: 37 in. long and 10 in. wide. The MK19 is 43.1 in. long and 13.4 in. wide.

The MK47 is also equipped with a Raytheon AN/PVG-1 video sight. This features a display with image intensification and night vision, a laser rangefinder and ballistic computer.

Some reports suggest the sight could be replaced by the Rheinmetall Vingmate Fire Control System (FCS), which includes a day camera, thermal camera, digital magnetic compass, GPS, laser rangefinder and laser pointer. The Vingmate FCS allows target acquisition up to 4,500 meters (15,000 ft.). It is in use by New Zealand on H&K 40-mm grenade machine guns.

AUSTRALIAN DEFENSE MINISTRY

The MK47 lightweight automatic grenade launcher from General Dynamics is portable, highly accurate and lethal.

The MK47 grenade options are varied. The weapon fires NATO high-velocity rounds, as well as MK285 airburst ammunition from General Dynamics and Nordic Ammunition Co.

Deliveries are scheduled to be complete by mid-2017.

—Pat Toensmeier

Think Tanks

Russia redesigns turrets, chassis and weapons for tracked vehicles

David Eshel Nizhny Tagil, Russia

ALL PHOTOS TAMIR ESHEL/DTI

The Armata family of tracked armored platforms recently made its second public appearance, at the Russia Arms Expo 2015 in Nizhny Tagil, Russia, with displays of the T-14 tank and T-15 BMP infantry fighting vehicle (IFV). Built on the common Armata chassis, they will eventually replace the T-72 main battle tank, armored personnel carriers and other tracked platforms in the Russian military.

The T-14 turret has a ROWS and sight on top, active protection system and panoramic cameras.

Also on display was the Koalitsiya self-propelled 152-mm artillery system. The gun's current hull is a derivative of the T-72, but future serial production vehicles are also likely to be based on the Armata chassis, thus gaining the advantage of matching the off-road mobility and sustainability derived from a fleet with common platforms.

This was the first time the armored vehicles had appeared in public since their debut in Moscow during the May Day parade. No noticeable difference was seen from those that traversed Red Square on that day, although this time only one example each of the T-14 Armata tank, T-15 IFV and Koalitsiya gun were displayed in a guarded corral, which allowed viewing by spectators from a safe distance.

First impressions clearly indicate a family resemblance, at least for the T-14 and T-15. Though the two vehicles have a common chassis, the directions are reversed, with the tank engine in the rear and the BMP's power pack in front.

Both vehicles are fitted with what seems to be an integrated armor suite that looks heavier than those of the T-72 and T-90 tanks. The absence of add-on modules, or even add-on armor mounts, hints at the use of new and improved protection modules, at least in the hulls. Previous Russian tank designs used reactive armor modules extensively. The new family does not have the tiles that indicate reactive armor but likely shares those capabilities as part of an integrated armor suite.

The turrets of the vehicles set each platform apart from the others. The T-15 turret seems to be the most mature, employing the Epoch Almaty system designed by KBP Instrument Design Bureau. This remotely operated turret mounts a single 2A72 30-mm cannon with 500 rounds, coaxial 7.62-mm machine gun and four laser-beam-riding AT14 Kornet EM guided anti-tank/anti-materiel missiles. The turret has redundant, independently controlled optronic systems, enabling simultaneous operation by the crew of two onboard weapon systems. Both modules have a guidance kit supporting the Kornet missile system, possibly enabling the simultaneous guidance of two missiles launched at two targets.

Note the smooth exterior, absent of add-on armor attachments on Russia's T-14 Armata tank.

The T-14 has a new unmanned turret, mounting a 2AD82-1M smoothbore 125-mm cannon. The turret is equipped with an automatic loader and ammunition-feeding system, enabling remote operation from the crew compartment in the hull. Forward of the weapons complex, the crew compartment has three positions—for driver, gunner and commander—and is isolated from the rest of the tank by armored bulkheads.

The T-14 shares the latest ammunition line developed for the T-90MS tank variant, including armor-piercing discarding sabot and high-explosive anti-tank rounds, as well as a new high-explosive/fragmentation round optimized for urban engagements against infantry and structures. For long-range engagement, the T-14 and T-90MS rely on the 9M119M Refleks gun-launched, laser-beam-riding guided missile.

The concept of operation relying on remotely operated weapons is also implemented in the highly automated Koalitsiya gun. Three crewmembers are seated in the hull, while the weapon, ammunition, loading systems and gun-

Armament for the Koalitsiya 152-mm gun includes a fully automated ROWS.

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The modernized BTR-80 is fitted with external slat armor and internal spall liners to improve survivability, particularly against rocket-propelled grenades.

laying and target-acquisition systems are in an unmanned turret above.

With crew seated low in the hull, both the T-14 and T-15 use active protection systems and multiple cameras to provide situational awareness and panoramic views. The T-14 has eight cameras embedded in the turret, on each face. The T-15 uses twin camera blocks on each side, and single cameras on the front and rear, in addition to a larger camera assisting the driver.

Apart from the Armata platforms, unmanned, remotely operated weapon stations (ROWS) were seen in other displays, including a modernized version of the BTR-80 8 X 8 vehicle unveiled by Uralvagonzavod and two new variants

The 6S21 ROWS in the BTR-80 clears much space inside, improving ergonomics for the crew and troops.

of the BMP-3 developed by vehicle manufacturer Tractor Plants Machinery and Industrial Group. The latter are part of the company's modernization plan for the BMP-3, which takes advantage of the reduced weight and increased volume of under armor provided by the ROWS. The new design has more spacious seating for a squad and two weapon-operation positions, for commander and gunner.

The vehicle is offered with three optional weapon stations, all remotely operated. The Dragoon unmanned turret mounts the standard 2A70 100-mm cannon, 2A72 30-mm automatic cannon and 7.62-mm PKTM machine gun. Another option is the AU-220M turret, designated Derivative, mounting a new stabilized 57-mm cannon with 200 rounds. Unveiled earlier this year at the IDEX expo in Dubai, Derivative, developed by CRI Petrek, can be integrated on various armored platforms, including the T-15, Kurganets 25 and Boomerang 8 X 8 vehicles, all currently mounting the Epoch system.

In addition to offering higher-caliber firepower over the current 30-mm cannon, this turret is expected to accept an additional load of guided missiles, extending the vehicle's effective range against different battlefield targets (short of main battle tanks) to 6,000 meters (19,686 ft.). The weapon's high elevation will enable BMP-3s with Derivative to effectively engage targets in urban areas—as well as unmanned aerial vehicles and helicopters—at a range of 8,000 meters, according to data provided by the manufacturer.

The BMP-3 IFV will also be offered with an unmanned turret mounting a low-recoil variant of the 125-mm smoothbore cannon, the same cannon used on the current Sprut tank destroyer, but remotely operated. This version was not on display at the expo.

Fitted with an unmanned turret, the BMP-3 IFV becomes a more efficient and ergonomic platform. In the Dragoon variant, moving the engine to the front enables a redesign of the fighting compartment for greater accessibility, with troop seating comprising two three-seat benches rather than the campfire-like seating around the turret that characterized previous designs.

The new configuration of the BTR-80 8 X 8 armored vehicle adds the 6S21 ROWS, mounting a 14.5-mm heavy machine gun controlled via an electro-optical set comprising video and thermal cameras.

The vehicle is designed with spall liners and slat armor for improved crew protection. Video surveillance cameras surround it, providing better situational awareness under armor, an obvious asset in combat, particularly in urban areas. The ROWS improves weapon operation by adding weapon and optronics stabilization and by integrating a TV and thermal imager, as well as a laser rangefinder. Weapon operation and control is available from the gunner and commander positions, using the system's displays and controls.

The BMP-3 prototype has an AU-220M-derivative turret mounting a 57-mm automatic cannon.

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Rapid Response

NATO exercise tests alliance's readiness for new threats

Nicholas Fiorenza Brussels

NATO's largest training exercise in more than a decade, Trident Juncture 2015 (TRJE15), is underway in Europe, the Mediterranean, the Atlantic and even Canada.

TRJE15, which began Oct. 3 and runs to Nov. 6, involves more than 36,000 troops and personnel from the 28 alliance members, plus partner countries Austria, Bosnia-Herzegovina, Finland, Sweden and Ukraine.

Its goal is to train and test the newly reinforced NATO Response Force (NRF)—including land, air, maritime and special forces—and certify Joint Force Command (JFC) Brunssum to be on standby to command and control the force if it is activated in 2016, when NATO wants NRF at full readiness.

The NRF is being enhanced as part of alliance measures to reinforce NATO's Article 5 collective security guarantee to Eastern European members nervous about Russian involvement in the fighting in Ukraine.

The exercise will also certify NRF components: NATO Rapid Deployable Corps Spain; Joint Force Air Component (JFAC) in Italy; U.K. Maritime Force; U.S. Special Operations Command Europe; and the Polish Chemical, Biological, Radiological and Nuclear (CBRN) Task Force.

British Army Lt. Gen. Phil Jones, chief of staff of NATO's Supreme Allied Command Transformation (ACT) in Norfolk, Virginia, which is organizing the exercise, describes it as "a keystone event for NATO as we shift our focus from over a decade of really intense counterinsurgency to start to recalibrate our posture for the current security environment. This exercise," he notes, "is a focal point for testing, validating, experimenting, developing and training our joint forces at the scale, scope and level of complexity that our current and future security challenges demand."

ACT's Joint Warfare Center of Stavanger, Norway, developed the nearly 4,000-page exercise scenario dubbed "Sorotan." ("Sor" means "south" in Norwegian and "OTAN," of course, is the French acronym for NATO.) The scenario describes political instability, ethnic tensions and socioeconomic problems, exacerbated by a water shortage in the fictional Cerasia region far from NATO territory. These factors lead to the nation of "Kamon" invading a weaker country "Lakuta" to seize a key dam. The United Nations gives the alliance the mandate to intervene in the face of hybrid warfare similar to that seen in Ukraine, as well as theater ballistic missile and CBRN threats. NATO also has to deal with violence against the civilian population. a humanitarian crisis and hostile government-controlled media.

Forces participating in Trident Juncture include more than 3,000 U.S. Marines and 12 MV-22 Osprey aircraft.

Alliance representative Oana Longescu says TRJE15 will "demonstrate NATO's ability to work with international organizations to deal with a crisis . . . [using a] comprehensive approach." More than 12 international governmental and non-governmental organizations are participating, including the European Union, Organization for Security and Cooperation in Europe and the African Union, as players or observers.

For the first time, defense industries have been invited to an exercise "to observe evolutions, with the aim of generating exchanges and to bring insights and perspectives to possible technological solutions for the future and to accelerate military innovation," Jones says.

TRJE15 consists of two parts: a command post exercise (CPX) Oct. 3-16, and a live firing and training exercise (Livex) that takes place Oct. 21-Nov. 6. The CPX covers the entire exercise area, from Supreme Headquarters Allied Powers Europe and JFC Brunssum down to the unit level in Italy, Spain, Portugal and offshore.

The Livex will be NATO's first large-scale exercise since its involvement in Afghanistan: Four brigade-size units and more than 60 ships and 140 aircraft will participate. Amphibious landings on four beaches, carrier operations and CBRN defense training are planned. Maritime forces in the exercise include 68 surface ships, nine submarines, eight maritime patrol aircraft, 12 MV-22 Ospreys and more than 3,000 marines.

U.S. MARINE CORPS PHOTOS

Amphibious landings are scheduled on four beaches during the live firing part of the exercise.

Opposing forces consist of 20 surface ships and four submarines, plus aircraft, across the Mediterranean and in the Atlantic.

The JFAC, based at Poggio Renatico, Italy, will command and control more than 140 aircraft in the exercise, including: Eurofighter Typhoons, Panavia Tornadoes, Lockheed Martin F-16s, Boeing F-18s, Aero Vodochody L-159s, Dassault Mirage 2000s, Saab JAS-39 Gripens, Bell Boeing MV-22s, Lockheed C-130s, Transall C-160s and Airbus C-295s, along with nine aerial tankers, three airborne early warning and control systems, helicopters, and unmanned air systems (UAS).

The aircraft represent assets of 16 NATO allies, as well as Finland, Sweden and Ukraine. Based in Italy, Spain and Portugal, these aircraft will support army, maritime and special operations forces with intelligence, surveillance and reconnaissance; close air support; troop transport; personnel recovery; and search-and-rescue missions.

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Arctic Plunge

U.S. interests rise as sea ice shrinks in polar ocean

Michael Fabey Washington

The U.S. Navy and Coast Guard are jockeying for better positions in the international race to better understand and accommodate—and even gain advantage from—the changing Arctic climate.

While both services continue their annual operations in the Arctic, melting ice in the region is creating new transit routes, greater access and increased competition for transportation, economic benefits and natural resources, prompting the Navy and Coast Guard to bolster their presence.

The Obama administration, for example, will propose to accelerate acquisition of a replacement Coast Guard heavy icebreaker to 2020 from 2022, begin planning for construction of additional icebreakers and call on Congress to provide sufficient resources to fund the "critical" investments.

The Coast Guard is already flexing more muscle in the Arctic. The cutter WAGB-20 Healy, homeported in Seattle, sailed to the North Pole recently, becoming the first U.S. surface ship to do so unaccompanied, the Coast Guard says. This is also only the fourth time a U.S. surface vessel has reached the North Pole, and the first time since 2005, the service notes.

The crew and science party on Healy, 145 in all, departed Dutch Harbor, Alaska, Aug. 9 in support of Geotraces, an international effort to study the geochemistry of the world's oceans. The expedition, funded by the National Science Foundation, is establishing baseline measurements of air, ice, snow, seawater, meltwater and sediment of the Arctic Ocean for future comparisons.

Healy is the Coast Guard's newest high-latitude vessel. It is a 420-ft., 16,000-ton, 30,000-hp ship, capable of breaking ice more than 10 ft. deep. In addition to statutory missions such as law enforcement and search and rescue, Healy serves as a research platform with extensive laboratory space, multiple oceanographic deck winches and berthing for 50 scientists.

Shortly after Healy's departure, the U.S. Navy fast-attack submarine SSN-21 USS Seawolf returned to its homeport of Naval Base Kitsap-Bremerton, Washington, following a six-month deployment that included scheduled under-ice transits and under-ice operations in the Arctic.

The Seawolf is helping to gather intelligence and research for naval operations in the polar region. For the Navy to operate safely in an increasingly accessible Arctic, it will need a better understanding of the changing environment and more accurate weather and sea ice predictions than are currently available. It also won't hurt to have new technologies to help ships operate more safely and effectively in ice-choked waters.

"The Office of Naval Research has extensive research on computer modeling and prediction of sea waves, ice movement, seasonal ice cycles and air-ocean interaction," says Navy Rear Adm. Mat Winter, chief of naval research.

"We conducted two polar transits, including a routine surfacing at the North Pole," says Cmdr. Jeff Bierley, Seawolf's commanding officer. "Operations under the Arctic are part of the Navy's continued commitment to maintain access to all international seas."

The Navy has been operating in the Arctic for decades. It is expected that present requirements will increase along with maritime traffic in the region, service officials say.

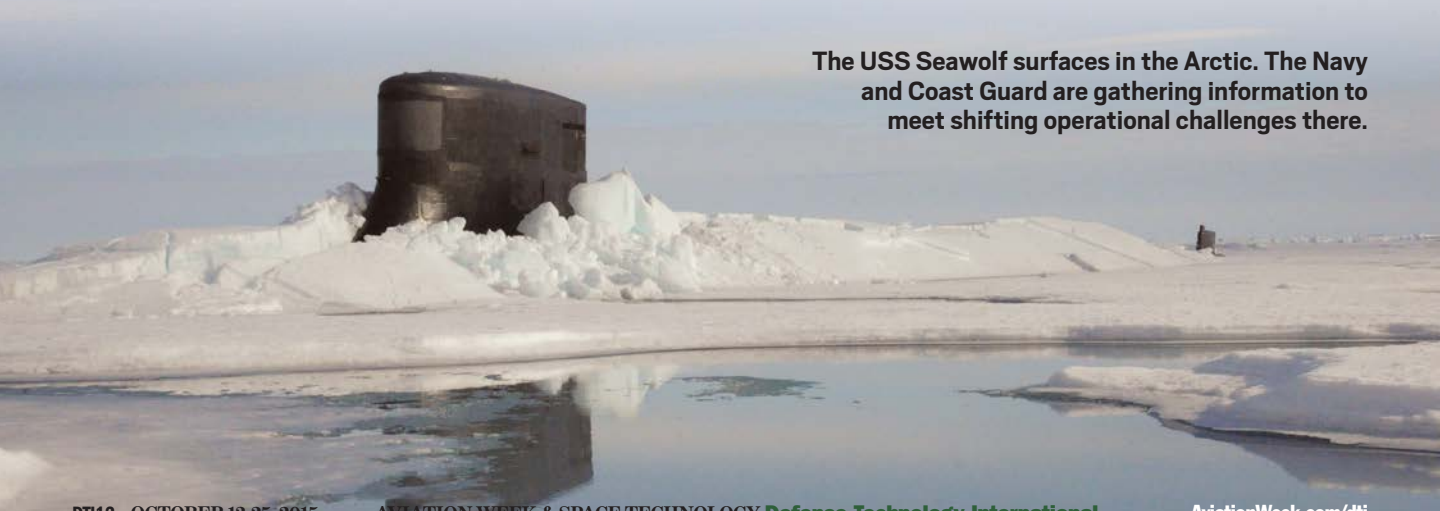
"Arctic transits are important, not just for us to be able to keep our fleet assets around the globe but [because] it also gives us an opportunity to maintain undersea dominance of the Arctic spaces, an area that is challenging and changing dramatically," says Capt. Douglas Perry, commander, Submarine Development Sqdn. 5.

Yeoman 3rd Class Felipe Aparicio describes surfacing at the North Pole: "As you push through the surface, it takes your breath away. You feel the ice hit the hull of the boat and you hear thumping back and forth all around you; then it just stops. It's a cold, snowy desert."

That "snowy desert," however, is becoming a geopolitical and economic hotspot—and the Obama administration says it needs the new icebreaker sooner rather than later.

After World War II, the Coast Guard had seven icebreakers in its fleet, four under Navy command. Today, it has only three, all under Coast Guard command. However, when age and reliability are taken into account, the fleet is down to the equivalent of two fully functional icebreakers and one heavy-duty icebreaker. Russia, on the other hand, has 40 icebreakers and 11 planned or under construction.

Climate change is reshaping the Arctic, the Obama administration maintains, with warming reportedly taking place almost twice as fast as in the rest of the world. Among the most noticeable changes is the retreat of sea ice. This past February, the sea-ice maximum reached an all-time low: about 1.1 million sq. km (425,000 sq. mi.) below average—an area more than twice the size of California.



U.S. NAVY

The USS Seawolf surfaces in the Arctic. The Navy and Coast Guard are gathering information to meet shifting operational challenges there.



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Lockheed Martin Long-Range Anti-Ship Missile (LRASM)
Northrop Grumman Global Combat Support System-Army

Sub-System Level R&D/SDD
Bell Boeing Armed V-22 Demonstrator
Rockwell Collins Joint Precision Approach & Landings Systems (JPALS)
Lockheed Martin F-16 Auto Ground Collision Avoidance System

Sub-System Production
CPI Aero Phenom 300 Engine Inlets
Lockheed Martin Solar Array Center
REO Sniper Advanced Targeting Pod Vacuum Cell Assembly

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Boeing C-40A
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Rockwell Collins F-18 Performance Based Logistics

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GE Adaptive Cycle Engine
Lockheed Martin Orion Crew Vehicle
Northrop Grumman Unmanned Combat Air System
Autonomous Aerial Refueling

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Boeing GMD
General Atomics-Aeronautical Systems MQ-9 Reaper Extended Range
Raytheon DDG 1000 Zumwalt Class Destroyer Program
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System Level Sustainment
Honeywell Satellite Control Network Contract
Northrop Grumman KC-10
Lockheed Martin Persistent Threat Detection System

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6:00-7:30 pm	**Registration** **Welcome Reception,** Alhambra Terrace & Foyer
NOVEMBER 4, 2015 - WEDNESDAY	
7:00-8:00 am	**Registration,** Alhambra Foyer **Breakfast,** Alhambra Terrace
8:00-8:15	Welcome Address and Introduction, Alhambra Ballroom
8:15-8:55	RENAISSANCE STRATEGIC ADVISORS
8:55-9:30	DELOITTE, LLP
9:30-10:05	PRICEWATERHOUSECOOPERS
10:05-10:35	Coffee and Tea Break, Alhambra Terrace
10:35-11:10	ELBIT SYSTEMS OF AMERICA
11:10-11:45	RENAISSANCE STRATEGIC ADVISORS
12:00-1:45	**Lunch,** Kasbah Patio
1:45-2:45	PANEL SESSION: THE END OF THE WORLD?
2:45-3:00	**Refresher Break**
3:00-3:45	BOEING DEFENSE, SPACE & SECURITY
6:00-7:00	Program Excellence Cocktail Reception, Alhambra Foyer
7:00-9:30	Program Excellence Awards and Dinner, Alhambra Ballroom
NOVEMBER 5, 2015 - THURSDAY	
7:00-8:00 am	**Breakfast,** Alhambra Terrace
8:00-8:10	Welcome Address, Alhambra Ballroom
8:10-9:00	PANEL SESSION: DIVERSIFYING - COMMERCIAL AND INTERNATIONAL VENTURES
9:00-9:10	**Refresher Break**
9:10-10:10	PANEL SESSION: BALANCING RISK AND REWARD IN THE EVOLVING A&D SUPPLY CHAIN
10:10-10:40	Coffee and Tea Break, Alhambra Terrace & Foyer
10:40-11:30	PANEL SESSION: PORTFOLIO AND INVESTMENT SHAPING
11:30-11:40	**Refresher Break**
11:40-12:25	PANEL SESSION: CONSOLIDATION WITHIN THE A&D SUPPLY CHAIN
12:25-1:05	Program Management Trends and Leaders
1:10	Closing Remarks
1:15-3:00	**BBQ Lunch,** Alhambra Terrace

AGENDA

	Sponsored by **Moss Adams** Sponsorship available
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	Joanna Speed, Managing Director, A&D Events - Michael Bruno, Senior Business Editor & Content Manager
	Opening Address - Jeff Roncka, Senior Partner
	What Now, What Next? Tom Captain, Principal & Vice Chairman, Global & U.S. A&D Sector Leader
	Megatrends - Scott Thompson, Partner
	Sponsorship available
	Leveraging Global Innovation for Successful Program Execution - Raanan Horowitz, President & CEO
	Technology Outreach: So What? - Jacob Markish, Principal
	Sponsored by **Arizona Commerce Authority**
	Moderated by Michael Bruno, Senior Business Editor & Content Manager, Aviation Week & Space Technology with CAPITAL ALPHA PARTNERS - Byron Callan, Director; GRUNDMAN ADVISORY - Steven Grundman, Principal and Lund Fellow, Atlantic Council; RENAISSANCE STRATEGIC ADVISORS - Pierre Chao, Founding Partner; SAMFORD GLOBAL STRATEGIES - Kenneth Krieg, Founder & Former Under Secretary of Defense for Acquisition **Discussions and Questions**
	Innovation for The Second Century- Steve Nordlund, Vice President of Strategy
	Sponsored by **PricewaterhouseCoopers**
	Sponsored by **AlixPartners**
	Joanna Speed, Managing Director, A&D Events Michael Bruno, Senior Business Editor & Content Manager
	Moderated by Michael Bruno, Senior Business Editor & Content Manager, Aviation Week & Space Technology with ARIZONA COMMERCE AUTHORITY - Sandra Watson, President & CEO; HONEYWELL AEROSPACE - Carey A. Smith, President, Defense & Space; ROCKWELL COLLINS - Steven T. Keane, Sr. Director, Air Transport & Mission Solutions, Simulation & Training Business **Discussions and Questions**
	Moderated by Kenneth Herbert, Managing Director, Canaccord Genuity with DELOITTE, LLP - Pete Heron, Principal; PARKER HANNIFIN - Peter Collins, Group Director, Strategic Planning - M&A; SPIRIT AEROSYSTEMS - Heidi Wood, SVP, Strategy; VERIFY - Alan J. McIntosh, President & COO **Discussions and Questions**
	Sponsorship available
	Moderated by Michael Bruno, Senior Business Editor & Content Manager, Aviation Week & Space Technology with ALCOA AEROSPACE - Margaret Cosentino, SVP, Business Development - Alcoa Defense; KEY BANC CAPITAL PARTNERS - Michael F. Ciarmoli, VP, A&D Equity Research; LAZARD - Michael J. Richter, Managing Director, Head of A&D Investment Banking Group; MOODY'S INVESTORS SERVICE - Russell Solomon, SVP **Discussions and Questions**
	Moderated by William Alderman, President, Alderman & Company with JAMAICA BEARINGS GROUP - Michael Mayer, EVP; THE MEREX GROUP, KELLSTROM DEFENSE & AEROSPACE - Christopher R. Celtruda, President & CEO; NOVARIA GROUP - Bryan D. Perkins, President & Co-CEO **Discussions and Questions**
	An outside panel of industry experts grades the annual Aviation Week Program Excellence awards. Here, members of the evaluation team will report on new trends and best practices emerging in 2015. Topics should include meeting affordability, budget and schedule concerns, as well as different approaches by OEMs and suppliers.
	Michael Bruno
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Bye Bye, Birdies

Radars separate birdlike UAS signatures from avian flocks to detect threats

Angus Batey and Bill Sweetman London

Unmanned aerial systems (UAS) present obvious attractions to military and security agencies. But the proliferation of small, low-cost, low-barrier-to-entry UAS—"drones" in popular parlance—poses a new problem for these agencies. As UAS become more popular, the need to prevent them from interfering with manned air traffic mounts, as does the threat of a cheap, off-the-shelf UAS being used to deliver an explosive, chemical or biological payload.

Conventional air-defense systems have trouble detecting small UAS. The aircraft are similar in size to birds, which primary surveillance radars filter out. Small UAS can be launched and operated close to a target, so there are limited opportunities to identify them as a threat and launch countermeasures

Falcon Shield from Selex ES tracks UAS with radar, identifies them with other sensors, then counters with electronic attack.

while they are inbound. And, even if ground-based air-defense (GBAD) systems are temporarily deployed around a sports stadium or political venue, firing a missile against a $3,000 UAS is unlikely to be proportionate or cost-effective and may cause more damage than the attack itself.

Emergent counter-UAS solutions rely on new or differentially optimized technologies in two areas: detect and defeat. Some vendors amend GBAD systems to enhance capabilities against small airborne targets. Other experts look at particular parts of the problem, principally in reliably detecting small UAS without an unacceptable rate of false positives. And efforts are underway to engineer systems-of-systems to tackle the problem holistically.

The U.K. Defense Science and Technology Laboratory, the Defense Ministry's research wing, has tested privately funded systems in Project Bristow, with the latest at the Royal Air Force West Freugh range in Scotland in May. Systems were tested against small UAS simulating potential threats, flying singly or in waves of several aircraft.

An upgraded version of Saab's Giraffe Agile Multi-Beam (AMB) radar showed it could discriminate between small UAS and seabirds. The radar incorporated features of the Giraffe AMB Mod C, extensively updated with hardware and software changes. The ministry ordered a number of new Mod C radars for the British Army earlier this year and will upgrade its Giraffe AMBs to the new standard.

According to a briefing by Saab at the Defense and Security Equipment International (DSEI) exposition in London in September, the radar detects birds and UAS with radar cross-sections of 10 sq. cm (1.5 sq. in.) or less at short range, while performing its normal air-surveillance functions out to 120 km (75 mi.). It uses a "secret sauce" blend of micro-Doppler functions and behavior detection to discriminate the two classes of targets.

American radar specialist DeTect Inc. of Panama City, Florida, approaches the problem from the opposite perspective. The company supplies customers—including the U.S. Air Force—with bird-detection radars for airports and bases, to assist in reducing bird strikes on aircraft.

"Detecting UAVs is quite simple for us—we're already doing that by default," says DeTect's general manager, Edward Zakrajsek. "The development for us is in categorizing them from birds and from each other. We foresee ourselves [providing] a long-range surveillance sensor, then pairing with more close-in sensors to do the final determination. The radar will select targets that are most likely drones, then steer the camera toward them to do the final verify."

Aveillant, of Cambridge, England, produces a novel concept, "holographic radar," for the counter-UAS role. The product does not acquire and track individual targets but scans the whole of the sensor's field: All movement data are processed and analyzed to provide surveillance of all objects in the airspace at once.

SELEX ES CONCEPT

"Once you've got the information into the processor, you then have to find [the UAS]," says Aveillant's chief technology officer, Gordon Oswald. "But that's a computing problem, not a laws-of-physics problem. And computing gets cheaper all the time." The technology was also tested in Project Bristow.

"In that part of Scotland, there are hundreds of seabirds, and we were detecting them and the drones out to about 4 mi.," says Oswald. "During the test, we could see by eye pretty well from the radar screen which were the drones and which were the birds, but what is required is an automated way of doing it."

Using data acquired during Project

Bristow, Aveillant is building software to automatically distinguish between birds and small UAS. The processing takes place in two stages. "The first stage is to use the information the tracking system on the radar has available to it, and we've just completed demonstrating that we can achieve 90% separation between drones and birds with that level of processing," says Oswald. "The second stage discriminates between birds and drones based not only on the tracker data but the Doppler signals we have. Any other radar that does not stare at all its targets does not have the quality of Doppler information that we have."

CHESS DYNAMICS

Once detected, of course, an effect needs to be brought to bear on the UAS if a perceived threat is to be mitigated. Several unique solutions are under development.

The German defense contractor Rheinmetall believes the small UAS threat is a good first application for its advances in laser weapon systems (*DTI* March 30-April 2, p. 6). The company has demonstrated the ability to shoot down small UAS using three laser projectors mounted where a single gun barrel would be in a conventional GBAD turret. The tracking system is identical, with an additional processing stage to focus the beam fired by each of the three lasers on a single point on the aircraft. Where destroying the target is unnecessary or potentially dangerous, an option is to "blind" it by firing the laser at optical sensors on board.

Jamming or inhibiting communications with the target aircraft is another option, and a British consortium launched what it says is the world's first specialized, integrated counter-UAS system in May to leverage that capability. The AUDS (Anti-UAS Defense System) comprises a K_u-band electronically scanned air-security radar from Blighter Surveillance Systems, electro-optical and thermal-imaging cameras and tracking software from Chess Dynamics, and a radio-frequency inhibitor/jammer from Enterprise Control Systems (ECS). The consortium says AUDS tracks, identifies and disrupts micro-UAS at up to 2 km and mini-UAVs at ranges of several kilometers.

Downing a UAS with jamming technology raises questions about collateral effects, even as it mitigates damage caused by debris from a downed aircraft or activation of its payload. Speaking at DSEI, Paul Taylor, ECS business development manager for Europe, accepted that some of his company's counter-UAS defeat mechanisms could impact other air traffic in the vicinity. Short bursts of GPS jamming might be sufficient to defeat many current commercially available drones, causing them to either crash-land or lose contact with their controllers. Taylor argued that brief interruptions in GPS service for conventionally piloted aircraft would not result in unrecoverable conditions and so represent a manageable risk in situations where the threat from an armed terrorist drone is significant.

Selex ES launched its Falcon Shield at DSEI; it unites detect-and-defeat mechanisms with low-collateral considerations. The company has been working on the system for three years and was a participant in the preliminary round of Project Bristow trials in 2013. Falcon Shield is radar-agnostic (Selex integrated Blighter and Saab radars), and once a track is acquired by radar, the system cues Selex's Nerio long-range optical and Horizon thermal/infrared sensors for identification. The system is modular, allowing new or additional sensors to be added, thus reducing the incidence of misidentification or false alerts.

Falcon Shield's key differentiators are in its defeat mechanism, which uses an electronic attack capability that the company declines to detail publicly, and an electronic surveillance element that permits identification and location of the UAS control station. (DeTect is working on this capability, while Aveillant's solution should permit users to trace a UAS to its point of origin by backtracking through data, provided the aircraft was launched from a point within the radar's field of regard.)

The AUDS counter-UAS system uses cameras and tracking from Chess Dynamics, along with radar and jamming technology from consortium partners.

"We are looking for emissions from the systems," says Stephen Williams, Selex capability manager. "We're going to give security services a tool that enables them to potentially take control of the vehicle. The attack capability is refined and means the system can be used across the full spectrum of environments, be they urban areas or sensitive industrial sites."

For lethal targets—a terrorist-controlled UAS with a chemical or biological weapon on board—a kinetic or energy-beam strike would risk dispersing the payload, as would a crash landing. Taking control of the aircraft appears to be the only safe option. While difficult, the task is not impossible.

"Even though there is a huge and growing market of vehicles out there, for most of them there's only a handful of suppliers for the controlling elements," Williams says. "Clearly, that's going to expand over time, and as the market develops we'll stay in pace with it. But at present it's limited, and we're reasonably confident that we understand what those systems are doing."

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Surveillance missions are key to lighter-than-air revival

Bill Sweetman Cardington, England

Hybrid Air Vehicles' (HAV) Airlander 10 made its first and so far only test flight, a 90-min. sortie out of Joint Base McGuire-Dix-Lakehurst, New Jersey, in August 2012 as part of the U.S. Army's Long-Endurance Multi-intelligence Vehicle program. Work started two years earlier with Northrop Grumman as prime contractor, but the Army canceled the project in February 2013 due to delays, budget cuts and shifting missions.

The cancellation was not a complete misfortune, CEO Steve McGlennan says. Had the program continued, "We would have ended up with a U.S. military-controlled project," he says. The British and U.S. governments instead brokered a deal in which the airship technology was released from export controls and returned unencumbered to HAV.

BILL SWEETMAN/AW&ST

A privately funded U.K. company, HAV plans to complete reassembly of the prototype by year-end, prior to a 200-hr. series of test flights under European Aviation Safety Agency (EASA) rules. The goal is to expand the envelope to 10,000-ft. altitude, 70-kt. speed and three-day endurance, in preparation for demonstrations to potential customers.

HAV is the latest in a series of companies—all based around the World War I-era airship hangars here—to promote the multi-lobe-hull airship concept. The late airship designer Roger Munk devised it to address problems of ground handling and loading. The hybrid operates slightly heavier than air (Airlander 10 is designed for takeoff weight of around 1 ton) and takes off with a short ground run. The wide envelope—with a flattened underside and curved top—generates lift and takes off at 35 kt. with a heavy load. The hybrid concept inspired the U.S. Defense Advanced Research Projects Agency's short-lived Walrus program, a massive craft with 500-ton payload.

The Airlander 10 has a fly-by-light flight-control system and is powered by four Technify/Continental 350-hp V-8 turbo-diesel engines driving ducted propellers, two fixed at the rear of the hull and two on vectoring mounts on the forward sides. Variable-volume air-filled ballonets inside the hull adjust buoyancy. The envelope and landing skids are made from a multilayered fabric comprising carbon fiber for strength, Mylar for gas-tightness and Tedlar for weather protection. Suspended from the envelope, and from the vertical curtain that defines the two lobes, are (front to rear): the control cabin, payload module, external payload mount and fuel tank.

The Airlander 10 is the first full-sized airship along Munk's lines and was designed and built in just over two years. This, says McGlennan, is the main reason for its excessive weight. "We know what we have to do to fix that," he says. The initial production Airlander 10 will be manned and designed for five-day endurance, whereas the Army wanted an unmanned configuration and 21-day endurance.

The next step after flight tests is likely to be a concept capability demonstration for the U.K. Joint Forces Command (JFC) focused on maritime surveillance, with Selex-ES as principal partner. This is a major capability gap for the U.K., following cancellation of the BAE Systems Nimrod MRA4 maritime patrol aircraft and retirement of the Nimrod MR2 force. JFC is reported to be taking a wide view of the maritime mission, from antisubmarine warfare to search and rescue.

Selex-ES is funding construction of a payload module by Forward Composites. Planned payloads include SeaSpray active, electronically scanned array radar; multiple electro-optical turrets; electronic surveillance measures; directed infrared countermeasures and the VigilX all-around enhanced-vision system. The module will also include the SkyIstar mission-management system—based on Selex's UAV ground-control station—bunks, a galley and restrooms.

The Airlander 10, 302 ft. long, with a volume of 1.34 million cu. ft., is midsize by airship standards but longer than any heavier-than-air aircraft.

McGlennan envisions demonstrations raising customer interest. HAV is in discussions with coast guards worldwide, as well as energy and shipping companies working in the Arctic. The market is "60% commercial and 40% military," but defense and government security customers are likely to be first in line, he says.

HAV is looking at unusual uses for the airship, such as midair launch and recovery of UAVs and launching and retrieving rigid-hull inflatable boats for maritime interdiction.

The company plans to raise money with an initial public offering toward the end of 2016, achieve EASA certification of a production Airlander 10 before the end of 2018 and produce up to six aircraft per year. The target cost is $40 million and operating cost is projected as $2,000 per flight hour.

HAV's philosophy is to mature the Airlander 10 before offering a larger cargo ship with a 50-ton payload. McGlennan mentions a "more electric" version, with batteries and electric motors replacing the forward engines. Electric motors are easier to use on vectoring mounts, improving control at low or zero speed, and the vehicle would have a silent mode for interdiction.

Orbital Relay

Nanosat constellation creates satcom link for lower-echelon ground forces

David Eshel Tel Aviv, Israel

An integration of terrestrial ad hoc mesh networking with satellite-based relays developed in Israel by Rafael could provide the missing link that has often kept tactical forces in the dark, in terms of communications, during combat.

Nanrec is a communications network based on nanosatellites that will reportedly enable tactical forces to link to high-level command, intelligence, combat support or friendly forces, whether across a street, over a mountain or thousands of miles away.

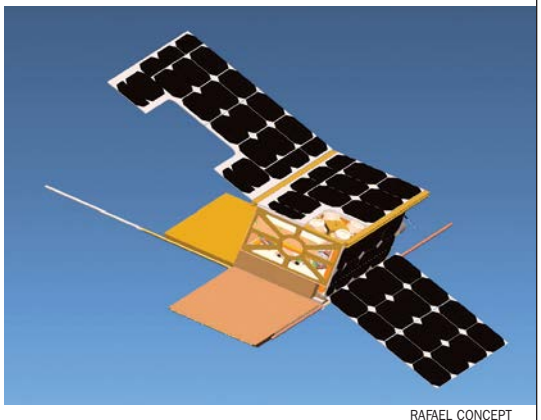
Weighing less than 33 lb., each Nanrec satellite will carry a small, lightweight, software-defined radio developed by Rafael for its new BNET radio family. The radio covers a frequency spectrum up to the K_a band, and monitors thousands of channels simultaneously, allowing the satellite to be part of several terrestrial ad hoc networks as its orbit crosses an area of interest.

Acting as a relay with what Rafael says is 100% availability, Nanrec provides beyond-line-of-sight communications to support tactical forces, either dismounted or mobile. The satellites enable communications between dismounted forces over a radius of 186 mi., and link forward elements and command centers more than 620 mi. away.

While individual satellites enter and exit an area of coverage several times per day, an entire constellation of up to 24 satellites will maintain continuous coverage of an area. A commercial vehicle such as the SpaceX Falcon 9 could launch and deploy a constellation of nanosatellites in low Earth orbit within hours.

Geosynchronous communication satellites orbiting 22,500 mi. above Earth typically need 250 millisec. to complete a "double hop" link across 100,000 mi. Nanrec constellations, however, use low Earth orbit to serve medium distances with single-hop topology, reducing latency to under 20 millisec., while increasing bandwidth performance.

Rafael says Nanrec relays will establish satcoms at more than 100 kbps. between two handheld radio sets with standard omni-antennas positioned anywhere within 300 mi. of each other, enabling the transfer of digital voice, data, maps and images. When linked to vehicular OTM (on-the-move) terminals, Nanrec's data rate could increase to 700-800 kbps., allowing low-bit-rate video links. Employed via stationary dish terminals, data rates could top 6 megabits/sec., permitting transfer of real-time video.



RAFAEL CONCEPT

With the capability, small units will communicate across "urban canyons" or mountain ranges inaccessible to standard radios. The system will give soldiers a link with clear voice and data communications, or allow them to access remote imagery from unmanned aerial vehicles without special equipment.

Moreover, as the satellites use BNET's ultra-wide-band and advanced electronic counter-countermeasures capabilities, they are relatively immune to interference and jamming.

Rafael also plans commercial applications for the Nanrec network, which could include extending an airspace control network over areas not covered by terrestrial radar stations.

While special forces operate under close supervision from high-level commanders, ground forces are often left to their own missions without close control, acting under guidelines set through a chain of command. This provides unit commanders with freedom and flexibility, but complicates things when they are needed to operate in a networked force or require support.

When tactical commanders need to reach back to higher command, establishing links takes time, requires support at multiple levels, and can be unavailable. Previously, satcoms were provided to units in fixed locations, connecting forward command posts to command centers, leaving mobile and dismounted forces dependent on short-range networks.

Special forces, of course, make extensive use of satcoms. This permits command-and-control links to span thousands of miles and allows the transfer of live video and other data from a warfighter's gear. In contrast, tactical communications for ground forces employ terrestrial networks, as well as devices that share common waveforms, combinations of frequency and hopping, modulation and encryption.

Nanrec satellites from Rafael are designed to form a constellation in low Earth orbit that facilitates radio communication between tactical combat troops.

Tactical networks are managed over central hubs, which cover the theater of battle, or by ad hoc networks where multiple devices sharing the network determine its reach and size. Each topology has advantages and limitations, but is limited to the tactical arena.

The lowest tactical echelons—squad, platoon and company—often employ VHF/UHF radio networks to transfer voice and data. Modern radio sets are designed to exchange images and videos, enabling squad and platoon leaders to provide real-time information to higher commands.

When done on a large scale, connecting these end points becomes a time- and bandwidth-consuming endeavor, as tactical radios are limited to line-of sight communications. To access the wide bandwidth connectivity required for network-centric operations, tactical communications need beyond-line-of-sight communications such as satcom links; hence, the importance of Rafael's nanosatellite constellation.

Hack Attack

Monetizing cybersecurity gaps can be lucrative, but contentious

Angus Batey London

In July, following publication of email messages stolen from Italian spyware manufacturer Hacking Team, some techniques of the cyberweapons market were revealed. In particular, the email showed how Hacking Team obtained zero-day vulnerabilities, perhaps the most controversial element of the cyberdefense industry.

Almost all software contains errors or omissions that provide a vector for attack by hackers. Conventional anti-virus or anti-malware programs are signature-based and provide no defense against previously unseen attack methods. An unknown security gap therefore has a high chance of permitting an effective attack and of the assault remaining undetected.

These susceptibilities are called zero-days, and their utility to those building offensive cybertools is obvious. Stuxnet, a software code weapon that destroyed centrifuges in an Iranian uranium-enrichment plant in 2010, leveraged at least four zero-day vulnerabilities to infect the devices and remain undetected.

Anyone with sufficient knowledge of the relevant systems, and fluency with the necessary code languages, can discover a zero-day vulnerability. To leverage it, attack code—known as an exploit—needs to be written.

Researchers finding zero-days often practice responsible disclosure; they inform the software vendor, which issues a patch to repair the code and close the security gap. The vendor then publishes details online. Many vendors pay researchers to discover such errors under "bug bounty" programs.

However, a market for zero-day exploits has developed. Prices range from the low thousands to more than a quarter-million dollars, depending on quality, breadth of application and scarcity, Hacking Team emails reveal.

Exploits for Apple's OS X or iOS platforms tend to command higher prices because of their scarcity, while an exploit for Adobe's Flash software—in which five zero-days were found in 2014 alone—may still command a good price if it permits administrator-level access across different platforms.

The market exists because bug bounty programs pay poorly compared to rates offered by those hunting for zero-days. Until recently, for example, Yahoo's payment to researchers discovering errors in its code was an online voucher for a T-shirt; and Apple, which reported revenue of $182 billion in 2014, does not even offer payment.

Tools such as RCS (Remote Control System), Hacking Team's primary product, rely on a steady supply of zero-days to be effective and undetectable. When a vulnerability that RCS uses to access a device or remain hidden in it is patched, RCS will continue to be effective only if another hole in the code is identified and exploited.

Cybercriminals also leverage zero-days, though most cybercrime results from known, unpatched security gaps. The Verizon 2015 Data Breach Investigations Report found that in 99.9% of more than 200 million incidents, exploitations took place more than a year after a patch was issued.

The sale of exploits is legal but contentious. Critics argue that by keeping details of vulnerabilities to themselves, security and police agencies leave everyone else exposed. Private companies broker sales of exploits to government and law enforcement. But heavy users may stockpile them, potentially leaving errors unpatched in systems, which criminals could exploit should they discover the gaps. Proponents of the sale of zero-days, however, claim that the trade to government agencies presents more opportunities to eradicate such crime than threats to the globally networked infrastructure.

In 2002, research collective SnoSoft found a zero-days in Hewlett Packard's (HP) Tru64 UNIX operating system. A member of the collective published an exploit online. HP emailed SnoSoft's co-founder, Adriel Desautels, threatening legal action, but then backed down amid public criticism.

Desautels learned a lesson. "We believed that by disclosing vulnerability information and making vendors aware of it, patches would end up being created and people would apply the patches," he says. "But we realized that the majority of vulnerabilities we published had not been patched."

He discovered that patches had usually been created, but users were slow to apply them: "People do not seem to care [until] they've suffered a compromise."

So Desautels changed his tack. After establishing a new company, Netragard, he saw a need for a middleman to help independent researchers sell vulnerability research and exploits to buyers in security and law enforcement. The Exploit Acquisition Program (EAP) was the result: It is a zero-days brokerage with Netragard guaranteeing the work to the buyer and ensuring the seller gets the best price.

"In an ideal world," he says, "I would like to sell zero-days vulnerabilities back to the vendors, and I would like the vendors to pay fair market value and have people fix their software. That could happen if vendors implemented automatic patching that was not controlled by users. But if you did that, people who keep themselves vulnerable would be up in arms because their systems would automatically fix themselves and they wouldn't be in control."

Instead, EAP—using anonymous, trusted intermediaries—dealt with governments, law enforcement agencies and, occasionally, vendors who supplied those customers with surveillance tools.

A key feature of the acquisition program was vetting buyers. One EAP client was Hacking Team, but when the July email cache revealed that RCS

REUTERS/LANDOV

Former Iranian president Mahmoud Ahmadinejad tours the Natanz uranium-enrichment facility. The Stuxnet virus destroyed centrifuges there by leveraging zero-day vulnerabilities.

had been sold to agencies of regimes with human rights abuses, including Sudan, Ethiopia and Uzbekistan, Desautels ended the program. (EAP represented a very small part of Netragard's business, which focuses on penetration-testing services.)

"We only sold Hacking Team one zero-days exploit," he says. "But the idea of a country like Sudan getting their hands on that was enough to make me question whether [EAP] is going to be useful."

Regulation of the zero-days market exists, but only in some countries. Last year, the Wassenaar Arrangement export-control regime extended its definition of dual-use goods to cover computer code that could be used in surveillance. Italy, where Hacking Team is based, adopted the revised protocols in January. The U.S. is assessing implementation, with initial proposals apparently withdrawn after extensive criticism from industry and activists.

"This isn't the sale of an aircraft carrier. It's an industry where you can get something made for $50,000, and that market is going to exist even if we regulate it," says Mark Kuhr, cofounder and chief technology officer of cybersecurity company Synack, and member of the Coalition for Responsible Cybersecurity, an industry lobby group established in July to oppose the proposed implementation. "Arms control is useful, but there's also a giant black market for weapons. I'm not sure there's any type of legal compliance that's going to prevent the bad guys from doing what we don't want them to do."

"I think that regulation is necessary for people like Hacking Team, for people like Netragard, and any of these other companies that are in the zero-day industry," says Desautels. "You're providing people with the ability to compromise something in a covert manner and to do something that nobody else understands."

The industry and its critics seem to agree on the need for regulation, but questions of proportionality and the elimination of unintended consequences remain.

"[Critics and activists] are going to have a lot of influence on regulatory policy," says Eric Rabe, a Hacking Team spokesman. "We expect that the regulations will probably change. But these questions are much more complicated than most activists suggest."

National Treasure

'Prosperity Agenda' boosts outlook for U.K. defense industry

Francis Tusa London

GENERAL DYNAMICS UK

The first full prototype of the Ajax scout vehicle was unveiled during DSEi. The family of armored vehicles is the foundation for the British Army's new Land Joint Strike doctrine.

September's Defense and Security Equipment International (DSEi) exposition in London was more upbeat than its predecessor two years ago. One reason for this was a large U.K. military presence among attendees and speakers. The other, and doubtless the most significant, was budget pledges made in July that U.K. defense spending in fiscal 2016 would meet the NATO requirement of 2% of GDP and increase overall by "inflation plus 0.5%."

The main feature of most presentations was a concept first floated six months ago, which most didn't take seriously then but is now at the front of U.K. defense policy—the National Prosperity Agenda, initially known as the Defense Industry and the National Prosperity Agenda.

Put simply, this means there will be a "U.K. preference" when it comes to procurement. Defense Secretary Michael Fallon said in his DSEi speech, "Exports are good for defense, and what's good for our defense is good for our economy." Minister Philip Dunne, head of the procurement agency Defense Equipment and Support, spoke about exports and their impact on the U.K. defense industry. "It's about economic opportunity . . . helping those companies [defense contractors] to succeed helps our economy," he said.

In order to export capabilities and equipment, the U.K. must have relevant ones to sell. The implications are profound: If the words are backed up by deeds, then the allure of "buy American" will diminish and be irrelevant to access one of the largest markets in the world, where defense equipment spending is £8-9 billion annually ($12-14 billion), and support services account for another £4-5 billion annually.

There are two pending procurement programs in the U.K. that could be affected by this policy: the Apache Capability Sustainment Program, for which the Boeing AH-64E is the favored candidate (so far), and the possible maritime patrol aircraft (MPA), for which the Boeing P-8 Poseidon is in the running (see page DTI 20). As neither of these programs has any local R&D or production, the effect on "national prosperity" is nonexistent.

A revelation came from Army Chief of General Staff Gen. Nick Carter, who unveiled a doctrine called Land Joint Strike (LJS). There has been speculation in the U.K. that the British Army is drifting as the Afghanistan campaign winds down and that the Royal Navy and Royal Air Force are more favored, as they promise action with fewer boots on the ground. Until LJS was released, the Army was very much on the back foot, politically, doctrinally and in terms of budget.

LJS is meant to provide the means to "defeat hybrid opponents in complex terrain," Carter explains. "It is able to project at reach . . . and exploit agility. . . . A key word to describe [the concept] is 'elasticity.'" He envisions it coming into force about 2020-21, when the U.K. also wants to declare its planned armored infantry brigades fully operational.

LJS is the application for the Ajax family of armored vehicles—the new name for the Scout SV—the program that aims to provide the British Army with a new reconnaissance vehicle and is moving into the verification and validation phase of development.

"The Ajax armored cavalry vehicle is the core equipment for LJS," says Carter. "It will be task-organized with a [new] infantry variant." This latter vehicle is the Mechanized Infantry Vehicle (MIV), previously known as the Utility Vehicle (UV), which will almost certainly be an 8 X 8. Reports say the Army has decided to test two vehicles for this role: the Nexter VBCI and the General Dynamics Stryker. Ironically, the UV program of the mid-2000s rejected both vehicles.

The requirement for LJS is demanding: "It will operate beyond the usual range of combat support," Carter says. "It will have low logistic needs. It will self-deploy and self-sustain up to distances of 2,000 km [1,243 mi.]. It represents a new means of getting around the anti-area-access challenge."

The deployment distance is a key issue for the Army. There has been much study, and admiration of the French army's campaign in Mali in 2013. During this drive, VBCI vehicles were shipped to Dakar, Senegal, from which they self-deployed 1,300 km to Bamako in Mali, and continued to operate in the combat area for months afterwards. Why the U.K. requirement is for a 50% longer distance, however, is unclear.

It is worth noting that there were several briefings at DSEi about the Ajax family. The common base vehicle—the chassis that all models will be based on—weighs 25 tons, leaving 17 tons of extra payload, made up of a turret for variants need-

ing that (weights were not provided by General Dynamics or the Army), or extra armor. Protection comes in two scalable packs, active and passive. The first is for major combat operations (MCO), with an emphasis on direct-fire weaponry; the other is for peace-support operations (PSO) and focuses more on improvised explosive devices and similar threats. The MCO-armored scout vehicle (also called Ajax) will weigh 38 tons, leaving 4 tons for growth, a 10% margin.

The other major difference between the main variant of the Ajax scout vehicle is that in the MCO fit, it will have a Thales primary sight for surveillance and target acquisition, whereas in the PSO fit, that will be replaced with either a Kongsberg 50-caliber machine gun, 7.62-mm machine gun or 40-mm grenade-launcher remote weapon station.

Six variants are scheduled for production: 245 Ajax scout vehicles (with 40-mm case telescoped ammunition turrets made by Lockheed Martin U.K., the only turreted variant), 93 reconaissance-support armored personnel carriers (APC), 112 command-and-control vehicles, 38 equipment recovery vehicles, 50 equipment repair versions and 51 engineer reconaissance variants.

The Ajax family will have a range of 500 km, so a planned LJS operational range of 2,000 km will still require a substantial number of fuel trucks.

Meanwhile, Lt. Gen. Alexander Schnitger, commander of the Royal Netherlands Air Force, made interesting observations about aircraft procurement in his presentation at the pre-DSEi Rotary Systems to 2030 conference.

"The F-35, a common aircraft for all services and international customers, [was so large that it] led to delays and cost rises. The [AgustaWestland] NH90 [tactical transport helicopter] has 23 different configurations—more than there are customers—and a 10-year delay. Both took 20 years from requirements to [initial operational capability]," he remarked. "Huge international programs . . . are probably not the best way to bring equipment into service. I think that [in the future] we will look to processes based on open innovation, not closed."

The Netherlands may be another country that will not buy into the "big production is beautiful" idea in the future.

U.K. DEFENSE MINISTRY/CROWN COPYRIGHT

Defense Secretary Michael Fallon examines an Ajax weapon station. Fallon discussed the National Prosperity Agenda at DSEi that will be a key element of procurement policy once the U.K. Strategic Defense and Security Review is published in November.

SAAB

Hakan Buskhe

President and CEO of Saab Group

Age: 51

Experience: Became Saab Group CEO in November 2010. Early in his career, Bushke was a production director with Carlsberg brewing company; he later became CEO of Carlsberg and Coca-Cola Distribution in Sweden. He subsequently served as CEO of Swedish divisions of the Schenker logistics group and president/CEO of the Nordic and Sverige divisions of energy group E.ON.

Education: Masters of Science, Licentiate of Engineering, Chalmers University of Technology, Gothenburg, Sweden

Laurel-Free Zone

The motoring world was once divided between people who liked Saab cars and people who knew little about them. The same could have been said for Saab defense a few years ago, but not today. Since Hakan Buskhe's arrival in 2010, Saab has launched the almost-all-new JAS 39E Gripen fighter and established a joint venture with Embraer to build it; seized pole position in the race to exploit gallium-nitride-based radar technology; and bought the Kockums shipyard and cut metal on an advanced submarine. Plus, the U.S. Air Force's next trainer could have more Swedish content than a potluck dinner in Minnesota. But with a quadrupled backlog, how does Saab remain Saab? DTI *Editor-in-Chief Bill Sweetman asked Buskhe about this at DSEi in London.*

***Defense Technology International:* How does Saab remain agile as it expands in business?**

Buskhe: The key is not to take anything for granted. If you rest and pay too much attention to your successes, you lose. We have gone from €3 billion ($3.35 billion) to €12 billion in our order backlog. We now have a risk, internally, where people say, "We have things to do for the next seven or eight years." That is something I am working with every day, to create the right mindset and tell people we have just started.

I keep the organization focused on profitability, project success and cash flow. It should not just be the CEO sleeping badly at night. I make sure my employees have the right tools and resources. I challenge them on those resources, but they should not come and tell me, "We couldn't do this because we didn't have the right authority." You have to be problem-oriented. We have a good product range that is affordable, and we have fairly good productivity; but we have to do better.

"No excuses" in your book means asking for help when needed?

Yes, and I must be clear that you need a culture where people can speak. I encourage people to say what they [are thinking]. If you're on the workshop floor, if you know something is wrong, you have to say "Stop, I don't agree with you." Then we can have a discussion. But when we have decided something, we need to go forward. And if people would like to go another route, it [becomes] another company. They have to choose.

The world of new technology is spinning much faster today than five years ago. We know what will happen in the next five years, so if we don't train and get in shape to handle that, we can never do it.

Submarines are a new and specialized business for Saab. What is your approach to managing that enterprise?

What I told Kockums when I took over was that there are two things I will not compromise: the working climate—health and safety—and efficiency. I think those two go hand in hand. We need to build Saab Kockums to withstand international competition, not just match the price a Swedish customer can pay.

We took over tremendously skilled people, but we have also moved some of our skilled business and production leaders from aeronautics. They are bringing in new processes, solutions and approaches to quality, and it looks promising.

The CEO needs to understand the configuration of a project and the technology. You don't need to be an engineer, but you need to show an interest, to understand the theory of the pressure hull and the sensor setup—the same as for the Gripen. If you do that, you don't increase the engineering skill level, but you can be involved in the discussion, in understanding the difficulties of building these machines. You can talk to the people who are doing the welding, the maintenance, and understand what they can do better, and you can be a better partner in discussion with the management.

Is there a potential problem with sending aeronautics people into a submarine division?

You have to have respect for each other's knowledge, but that doesn't mean that, because you have knowledge in a certain area, you can't learn more. My motto is "I always have more to learn than I know, each and every day." I don't believe at all when I bring people from aeronautics to Saab Kockums that they can contribute to better submarines, but they can come up with new ideas, new processes.

HARRIS

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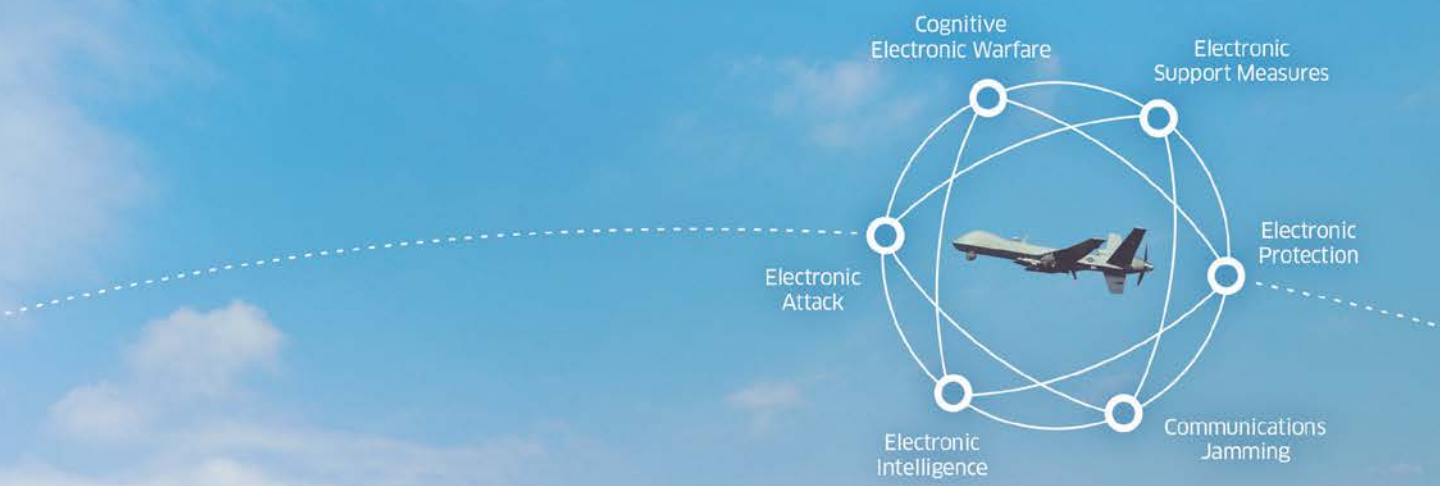

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because the Chinese air transportation industry is so much larger.

Estimating global demand for 8,500 aircraft with 200-350 seats in 2023-42, the manufacturers expect to sell 850 Lrwbcas. That figure seems to assume substantial exports. Again, Russia's diplomatic circumstances may limit the program's potential in that regard. In any event, use of Western systems should exclude use of the aircraft as a tanker by the Chinese and Russian armed forces.

The preliminary design of the Lrwbca is most closely comparable with the Boeing 787-10 and Airbus A330-900, with a similar range of 12,000 km (6,500 nm) but a markedly lower gross weight of 208.8-234 metric tons (460,300-515,900 lb.).

The designers have chosen exactly the same cabin width as the Airbus A350—5.61 meters (18.4 ft.)—and therefore standard nine-abreast economy seating. But, having less range, the aircraft would have a smaller wing, with a span of 58-61 meters.

Seating is hard to compare, because manufacturers can choose different pitches and class mixes. For the Lrwbca, Comac and UAC are aiming for 258-280 seats in three classes, 261-291 in two classes, and 321-426 in an all-economy configuration.

The greatest aircraft length Comac and UAC are considering, 63.43 meters, is almost identical to that of the eight-abreast A330-900, so the Sino-Russian aircraft should accommodate many more passengers if seating standards are similar. The 787-10 is 5 meters longer, however. It is narrower than the A350, but can accommodate nine passengers abreast with tight seats and aisles.

The Beluga XL will enter service in 2019 with Airbus Transport International (ATI). Five aircraft are to be built.

AIRBUS

fore the end of this year. A350 production rates are also increasing. One variable is future output of the A330—Airbus is slowing it down from 10 to six aircraft per month ahead of the transition to the A330neo, but hopes to return the program to the higher earlier levels once production of the new type has been phased in.

Transport requirements for the A350 in particular have triggered the launch of the Beluga XL. The current A300-based Beluga can transport only one A350 wing at a time, but the XL can take two, effectively doubling the capacity for this particular kind of shipset. It can also take fuselage sections of an A350 and a single-aisle aircraft, which will make the in-house transport system more efficient. The XL is six meters (20 ft.) longer and one meter wider than the standard Beluga, and it has a six-ton payload advantage.

However, should Airbus need more lift, it can extend the life of the Beluga fleet, which it plans to retire by 2025. While that may lead to more capacity than is required, one solution being looked at is to reenter the outsize cargo charter market. Airbus had previously offered a share of the available Beluga flight hours to third parties, but has effectively stopped doing so because all the capacity is needed internally. The first of the five aircraft in service now started flying for Airbus in 1995, and four more have since been delivered.

Connecting the Dots

Norwegian adds Ireland for next stage of long-haul expansion

Cathy Buyck Brussels

Norwegian Air Shuttle's announcement about its plans to launch transatlantic flights from Ireland and that it is nearing a deal with its—much larger—Irish low-cost counterpart Ryanair about feeding its long-haul network makes one wonder: Is more going on?

The airlines do have a lot in common. Both are fanatical in their efforts to drive unit costs down, growing rapidly (much to the annoyance of Europe's legacy network airlines) and have a proclivity for Boeing aircraft. Ryanair operates a single fleet of Boeing 737-800s and is launch customer for the 737 MAX-200; Oslo-based Norwegian also has an all-Boeing fleet—737s and 787s—and is European launch customer for the 737 MAX-8.

Transatlantic ambitions unite them as well. Each seeks

NORWEGIAN AIR SHUTTLE

to use the ope- skies agreement between Europe and the U.S. to offer low-cost flights between the continents. For Ryanair, these plans are on hold because it can't acquire a large enough batch of widebody aircraft at what it calls a "viable" cost because production slots are fully booked for the next couple of years. Norwegian, however, is already offering low-cost transatlantic services from London Gatwick Airport and several airports in Nordic Europe with 787-8s. The airline received its eighth 787-8 in April and the aircraft has been allocated to the Gatwick operations. A further 11 787-9s are on firm order, with deliveries starting next year and running through 2018—four will be delivered in 2016, five in 2017 and two in 2018. The 787-9 will be fitted with 344 seats: 35 in premium and 309 in economy.

Norwegian CEO Bjorn Kjos is so confident that he will be able to place all 19 787s, he is looking to buy many more. Cooperating with Ryanair will help fill the long-haul twinjets.

In what would be a nightmare situation for major airlines in Europe and the U.S., Ryanair could possibly even operate the 787s in its own right and file an application with the U.S. Transportation Department for a foreign air carrier permit and exemption. It seems very unlikely the agency would put Ryanair, Europe's largest airline in passenger numbers, through the same drawn-out process as Norwegian Air International (NAI), Norwegian's Irish subsidiary. NAI, which has an air operator's certificate from the Irish Aviation Authority (IAA), made its initial application for a foreign carrier permit in 2013—it has been pending for more than 18 months, the longest such wait ever. The delay is linked to opposition from certain air carriers and labor groups in the U.S., which depict NAI as a "flag of convenience."

Norwegian and Ryanair are in talks about cooperating, including having Ryanair feed the Norwegian LCC's long-haul network, Kjos confirms. Norwegian has its own short- and medium-haul network in Europe to feed its long-haul network, he says, but "[Ryanair has] a much larger network. We have about 500 routes, Ryanair more than 1,500 routes, so together we have a lot."

Kjos says he would be open to similar agreements with other LCCs, such as EasyJet, but points out that "Ryanair has the largest network."

Meanwhile, Norwegian is enhancing its long-haul offering across the Atlantic with two new routes from Cork, Ireland, to Boston and New York that it intends to operate with Boeing narrowbody aircraft. The Cork-Boston services are planned for May 2016 and Cork-New York for 2017, when the LCC's first 737 MAX-8 is due to arrive. Norwegian will also launch a 4-5-times-a-week service from Cork to Barcelona in May.

Madrid and Barcelona airports in Spain had been touted as likely bases for Norwegian's long-haul expansion, but the airline decided on Ireland.

With opting for Ireland, Norwegian is starting to implement the first phase of its 737 MAX network. The reengined 737 will be used on European routes, but its range also makes it capable of connecting smaller cities in Western Europe with the U.S. East Coast and bypassing larger hubs. Norwegian intends to deploy the MAX on a large part of its network to maximize daily aircraft utilization, crew efficiency and productivity. In 2012, the airline placed orders with both Boeing and Airbus to purchase a total of 222 aircraft—100 737 MAX-8s, 22 737-800s and 100 A320neos, with options for 100 MAX-8s and 50 A320neos. It is due to receive the first five of its 737 MAX order in 2017.

Norwegian is firming up plans to use Boeing 737-800NGs—and the new 737 MAX starting in 2017—on routes to the U.S. East Coast.

Norwegian plans to operate the Cork routes under its Irish subsidiary. Kjos says the two routes to Boston and New York are only the beginning of the LCC's plans in Ireland, but he emphasizes that the expansion plan hinges on NAI gaining foreign carrier permit approval from the U.S.

IAA Chief Executive Eamonn Brennan says the government body was "delighted to hear the announcement by Norwegian Air International of new direct services between Cork and the U.S." The new routes will be subject to the normal Ireland/U.S. approvals process, he notes, adding: "We look forward to these routes commencing."

Tony Lane, an IAA communications executive, tells Aviation Week that "it is envisaged that NAI will make an application for a point-to-point service in addition to continuing their current application."

Norwegian's planned Cork-Boston and -New York routes will be the only transatlantic flights to operate from Cork Airport. "The addition of direct year-round connectivity to North America has long been a target for Cork Airport, which has a robust business hinterland with a large cluster of U.S. multinationals and a fantastic tourism product," says the airport's managing director, Niall MacCarthy.

Room for Maneuver

Chinese officials have changed their mind about developing Beijing's main airport

Bradley Perrett Beijing

Beijing Capital International Airport aims to build itself up as an international hub, in part by adding a long-proposed fourth runway. The government also plans to construct a rail line connecting Capital with the new Beijing airport under construction about 70 km (43 mi.) away at Daxing, a district in the city's south.

These moves overturn a seven-year-old policy of undertaking no further major works at Capital and instead relying only on Daxing to meet Beijing's growing air-transportation demands. One result of that policy has been that, although Capital is the world's second-busiest airport, airlines operating there overwhelmingly focus on passengers going to and from China. There is not enough capacity at the facility to also handle the many foreign flights and large transfer traffic of a true international hub, but Daxing and the fourth runway, both to begin operation in 2018, will ease the pressure on Capital.

Although Chinese airlines carried 10.7% more passengers in 2014 than in 2013, Capital's numbers crept up by only 2.9%, to 86 million. The problem is not with its terminals. They are operating at about their designed capacity but, like terminals anywhere, could be pushed further at the expense of traveler comfort. Rather, the limiting factor is the runways. The current 1,600 movements per day is just about as many as they can handle—so long as the Civil Aviation Administration of China's air traffic management bureau maintains its policy of keeping unusually generous distances between aircraft.

With the fourth runway, Capital is due to handle 8 million more passengers per year, a 9% increase. The airport aims to increase international flights and passenger numbers to more than a third of its total by 2020, says Beijing Capital International Airport Co. Ltd., emphasizing the ambition to develop hub business. International passengers accounted for 24.1% of its traffic in 2014.

Airport managers have told Capital-based carriers that preference in granting slots will now be given to international services and they will seek more routes to other countries, says the *People's Daily*, quoting the company. As an international hub, Capital should present competition mainly to Seoul Incheon, Tokyo Narita, Shanghai Pudong and Hong Kong airports. Like those, it is well-located Southeast Asia-North America transfer traffic. It could also provide European, Middle Eastern and African connections for Japan and South Korea.

The operating company says the airport will promote the government's Belt and Road policy, through which China seeks deeper economic involvement with surrounding countries (the belt) and with those on the maritime route to Europe (the road). That implies more services to Asia and Africa, but the specific cities that the company mentions as priorities for connections are Berlin, Atlanta and Manchester, England.

The fourth runway, just 2,800 meters (9,200 ft.) long, compared with the 3,445-3,810 meters of the three current runways, will be used mostly for landings. It will be aligned north-south, like the others. To be built east of the easternmost current runway, it is described as supplementing that strip, apparently meaning the spacing between them will not be enough for them to operate independently. The modest 9% increment to passenger capacity also suggests close spacing.

SOURCES: BEIJING CAPITAL INTERNATIONAL AIRPORT CO. LTD./AVIATION WEEK ESTIMATES/GOOGLE EARTH

The fourth runway for Beijing Capital will be used mainly for landings, usually from the south.

Officials have previously told Aviation Week that the fourth runway may extend further south than the others, to avoid unnecessary demolition. For landings, generally from the south at Beijing, such placement would also minimize backtracking during taxiing to Terminal 3, the closest one.

As approved in December, Daxing will have three north-south runways and one lateral runway, though ultimately there may be nine, including one for the air force. Capacity will be 40 million passengers per year at first and 80 million when a second stage is completed. Plans allow for a final capacity of 130 million per year.

Another big change for Capital will be connection to the country's fast-rail network via Daxing. When the then-railway ministry began building high-speed passenger lines last decade, it largely ignored airports despite the obvious potential for aircraft to feed trains and vice versa.

Even as such rail lines have begun to connect to some airports, the country's busiest aviation facility, Capital, has remained unserved. A fast-train station has long been part of the plan for Daxing, and the government now confirms that a line will run from there to Capital.

The line cannot be very straight, because a direct path would cut through heavily developed parts of Beijing. And the location of the planned station at Capital is unclear, since the designers of its terminals appear not to have provided for one.

Despite the ambition of turning Capital into an international hub, a fast-rail connection would also have to increase domestic demand for use of the airport.

Safe Separation

U.S. AIR FORCE/CALSPAN

Basic ICAS operability was evaluated in the U.S. Air Force Test Pilot School NF-16 variable in-flight simulator test aircraft.

F-16 and Vista stress preliminary integrated collision avoidance system in Test Pilot School project

Guy Norris Los Angeles

With up to three pilots and their aircraft saved already by a newly introduced automatic ground collision avoidance system (Auto-GCAS), the U.S. Air Force and Lockheed Martin are starting tests of a follow-on system that will extend coverage of the safety device to prevent both air and ground collisions.

Initial flight tests of the integrated collision avoidance system (ICAS) were completed at Edwards AFB, California, in mid-September under a small student-led Test Management Project (TMP) at the Air Force Test Pilot School. The TMP, which was similar to those conducted for the early phases of Auto-GCAS and the recently completed automatic air collision avoidance system (Auto-ACAS), proved the basic concept by flying the school's NF-16D Vista (Variable Stability In-Flight Simulator Test Aircraft) in maneuvers against virtual targets and another F-16.

Auto-GCAS prevents ground collisions by projecting the aircraft's flightpath against the known terrain on a database, and if a collision is imminent and no action is taken by the pilot in response to evasion commands, the system automatically steers the aircraft to safety. The Auto-ACAS prevents air-to-air collisions by constantly building trajectories that look 4.5 sec. into the future. The trajectories change as Auto-ACAS systems on each aircraft cooperatively negotiate and evaluate automatic avoidance maneuvers, one of which is to roll and pull the aircraft. The system also works against noncooperative targets.

The key challenge to integrating the two systems is to avoid scenarios in which evading one threat might inadvertently put the aircraft in danger from another type of collision. In particular, the ICAS testing will ensure that an aircraft escaping an imminent air-to-air collision does not execute an Auto-ACAS maneuver that flies it into the ground, or in the case of an Auto-GCAS maneuver, does not initiate a fly-up to escape the ground that might lead to a collision with another aircraft.

"The idea behind ICAS is the Auto-GCAS will largely remain unchanged as a fielded system," says Lockheed Martin TMP ICAS integration lead Daniel Kidd. "We have to find a solution to integrate Auto-GCAS with Auto-ACAS without really modifying GCAS. The real challenge is to update ACAS to make it a more ground-aware system."

The objective of the recent flight-test program was to stress the ICAS algorithms, in particular when the logic was forced to make decisions between ACAS and GCAS maneuvers. The Vista aircraft was fitted with modified ACAS software and a pilot-activated version of GCAS. "We artificially raised the ground and made Vista think it was approaching the terrain, while it was also close to getting an ACAS activation," says Shawn Whitcomb, research engineering manager at Lockheed Martin's Skunk Works.

The ACAS activation was triggered by simulating the presence of a nearby aircraft or, in later flights, by flying an ACAS-equipped F-16 nearby. For additional safety the test was performed in an altitude offset mode that made the Vista believe the accompanying F-16 was above it, even though in reality it was below. The relative positioning stressed the algorithm into opting for an escape trajectory that prevented a ground collision yet did not endanger the nearby aircraft.

However, Kidd stresses, "GCAS always gets priority. The ground is big, and other airplanes are small. So if an aircraft is going to be in a GCAS fly-up and be with any wingman who might have the potential of an air-to-air collision, it is the responsibility of that aircraft to get out of the way in the event of that fly-up. We needed to find a way to transmit the GCAS fly-up trajectory to all other aircraft as an ACAS maneuver so they can receive that and know he's locked into a maneuver."

The second main objective was testing the air-to-air collision solution near the ground, says Kidd. "ACAS was not originally designed to account for terrain at all, so it can easily adopt a maneuver that could point you toward the ground. We therefore needed to alert the ACAS system and give it GCAS information to let it know it was close to terrain and only to calculate maneuvers that would steer you away from the ground."

A third aspect of the test evaluated how ACAS would respond in similar circumstances close to terrain if GCAS was unavailable or not responding. "In this case, the idea for ICAS is the pilot will be able to type a floor altitude and it would behave similar to a measured terrain altitude," says Bob Eller, Lockheed Martin flight controls and systems development engineer for Vista.

Tests looked at five different collision geometries for ICAS setup. These included a tail chase scenario, head-on collision, converging courses with a 90-deg. aspect, and two different turning scenarios with 20- and 60-deg. bank angles where the Vista was the lower aircraft and the other F-16 was positioned virtually higher.

The Test Pilot School project paves the way for a full ICAS evaluation program with the 416th Flight Test Sqdn. scheduled to begin March-April 2016. The recently completed work tested overall system operation and algorithm response and "helped us uncover the problems before we

start spending the big money with the 416th. We want to find the low-hanging fruit now, so we are more efficient when we get to the 416th," says Whitcomb.

In a related program, Lockheed and the Air Force Research Laboratory are planning a second phase of tests of a modified flight control computer that will enable older, analog-configured Air National Guard Block 30 F-16s to be equipped with the digital Auto-GCAS safety system now being installed in more recent Block 40/50 Air Force aircraft.

A Norwegian air force F-16 from European Participating Air Forces was used for hybrid flight control flight tests.

U.S. AIR FORCE/LOCKHEED MARTIN

The next test phase, scheduled for December, follows the successful completion of an initial 13-flight program at Edwards that evaluated the effect of the hybrid flight control system on flying and handling qualities, and demonstrated the feasibility of integrating the system with Auto-GCAS. Both objectives were met, says Whitcomb, who is also program manager for the F-16 hybrid flight control system.

"We hijack the pilot's stick and rudder signals," says Whitcomb. Speaking at the Society of Experimental Test Pilots conference in Anaheim, California, he said the hybrid system is produced by "integrating new digital cards in line with the existing analog cards. We didn't change the analog control laws at any time, and we came up with modifications that would meet airworthiness certification. We did this by creating a revert-to-mode of operation within the box. Essentially, a redundancy management system takes the new digital components out of line in a failure situation and reverts to the unmodified system," he added.

The flight tests will also be used to assess updates to the Auto GCAS algorithms already fielded in more than 500 Air Force F-16s. "There are a few areas where they've seen some potential nuisances, such as an aggressive split-S maneuver close to nadir, so this was an opportunity to do some experimental code development to see if we could improve them. We will get them into flight test for Phase 2," says Whitcomb.

The main focus for the next phase, which runs December 2015-February 2016, "is to mature the solution set for the analog aircraft," he adds. "So we cleaned up whatever nuisance trips we had, the system management, some pilot-vehicle interface areas and took care of a series of software improvements. We believe at the end of Phase 2 it will be at technology readiness level 7, or ready to accept into an integrated production solution without a lot of risk."

SIKORSKY

Helo Beast

Raider high-speed program takes off again as merger approaches

Graham Warwick Washington

Having flown its S-97 Raider high-speed rotorcraft a second time, Sikorsky is looking forward to the pending merger with Lockheed Martin and to working closely with the defense giant on making the light tactical helicopter mission-ready for potential customers.

The first Raider prototype completed a 1.2-hr. second flight on Sept. 29 at Sikorsky's development test center in West Palm Beach, Florida. The aircraft, which had undergone several upgrades since its maiden flight May 22, completed several takeoffs and landings, low-speed flight and the first run-on landings, says Chris Van Buiten, vice president for Sikorsky Innovations.

Aircraft 1 is not expected to fly again until the ground-based propulsion system testbed (PSTB), also at West Palm Beach, has completed 200 hr. of endurance testing on the Raider's General Electric YT706 engine, transmission, rigid coaxial rotors and tail-mounted variable-pitch propulsor. The PSTB has logged 32 hr. and plans call for 15-20 hr. of testing a week, says Dave Banquer, Raider chief engineer.

The second of the two industry-funded Raider prototypes, meanwhile, is essentially complete and will be displayed at the Association of the U.S. Army's convention in Washington on Oct. 12-14. While Aircraft 1 will be used for envelope expansion and demonstration of the Raider's key performance parameters (KPP), Aircraft 2 will be used for customer demonstrations.

Aircraft 1 has now logged 2.2 hr. of flight time and a total of 50 hr. run time including ground tests, says Van Buiten. Upgrades following the first flight include installation of the drag-reducing rotor-hub and interrotor fairings, and actuators for the moving tail and dual flight controls. Combined with a software upgrade, this prepares the Raider for higher-speed testing.

"Our big thrust now is to accumulate hours on the PSTB," he says. Work so far has focused on gear pattern development, says Banquer. This involves running the transmission, removing and inspecting the components, making "very minor" adjustments by grinding the gears and reinstalling them. "Typical aircraft go through three iterations," says Van Buiten.

The S-97 is a follow-on to Sikorsky's X2 technology demonstrator, which exceeded 250 kt. in 2010. The Raider is designed to cruise at 220 kt. carrying weapons on external pylons, and is capable of exceeding 250 kt. when clean—100 kt. faster than any conventional helicopter, the company says.

Since first flight, Raider has been upgraded with rotor fairings and an actuated tail.

This is enabled by the pusher propulsor and rigid coaxial rotors that delay retreating-blade stall at higher speeds.

The Raider program has KPPs for hover performance, high speed and maneuverability, the latter enabled by the rigid rotors and clutched propulsor. Envelope expansion will proceed through three phases. Block 1 covers normal helicopter speeds; Block 2, high speed and limited maneuvers; and Block 3 is full maneuverability at high speed.

With the latest software update "we are mostly good for Block 2," says Van Buiten. "We have a little more work for Block 3, which will include any discoveries from Block 2 testing." Kevin Bredenbeck, X2 test pilot and copilot to Raider chief pilot Bill Fell on both flights, took control for the first time on the second sortie. "He says Raider is a beast, in a good way, because of its installed power and control power," says Van Buiten. "He was impressed with the handling qualities, which continue to line up well with our simulations."

"The pilots are not griping about the software. They like the level of workload, and all the work in the simulation laboratory is paying off," says Banquer. The propulsor has been engaged on the ground, but not yet in flight. That and retracting the gear are among the next steps planned in flight testing. The PSTB, meanwhile, "has not quite reached 100% power, but we are very close," he says.

Interaction with potential customers has increased since Raider began flying, according to Van Buiten. "Flying makes all the difference, and we are having some exciting discussions," he says. "The level of interest is global, but the bulk of discussions are domestic because of export authorization. We have engaged the U.S. government for permission to have more in-depth discussions with specific international customers."

The dialog is not just with military customers but also with commercial ones, he says: "Existing Sikorsky customers and some in completely new [market] spaces see potential in the Raider's speed and other capabilities." Van Buiten says the 11,000-lb. Raider, which is designed to carry six troops, is about the right size for a six-passenger offshore-utility and "really good" four-passenger VIP helicopter.

"In VIP configuration, we can do New York-Washington and New York-Boston in an hour, and Cupertino, [California] to Los Angeles in 1.5 hr. Raider is a reinvention of the helicopter. That's the kind of thing you expect to see in Silicon Valley," he says.

Demonstration of the KPPs next year will conclude the Raider program within the Sikorsky Innovations research arm, with the military business unit taking over the prototypes for customer demonstrations. No date has been decided for flying the second aircraft, says Banquer.

Lockheed, meanwhile, is already a supplier on Raider, providing elements of the time-triggered Ethernet data network, and independently Sikorsky had begun exploring expanding the company's role in a follow-on phase to include more mission systems. "If the deal with Lockheed Martin goes through, we expect to work with them on what comes next," Van Buiten says.

Digital Extra *Read an update on Sikorsky and Boeing's SB-1 Defiant high-speed helicopter demonstrator at* **AviationWeek.com/JMR**

New Life for Old Cobras

BLR wants to give Bell's attack helo a new lease on life

Tony Osborne **London**


JMSDF

The AH-1 Cobra (pictured) is still in widespread use by Asia-Pacific countries including Japan, which has been slow to purchase the Boeing AH-64 Apache.

With its tandem cockpit, stub wings and narrow set fuselage, Bell's AH-1 Cobra set the design precedents followed by virtually every attack helicopter that followed.

And while it was retired from the U.S. Army service in favor of Boeing's AH-64 Apache, the Cobra is still in widespread frontline use across the world, notably in the Asia-Pacific region, where large numbers remain in service in Japan and South Korea, as well as with Bahrain, Jordan, Pakistan and Turkey in the Middle East.

However, without the backing of the U.S. Army, there are few real options to upgrade these still potent machines, which is why many Cobra operators are replacing the helicopter. Turkey selected the locally produced TAI T129 ATAK, while Pakistan is buying a mix of new-generation AH-1Z Venoms and Russian Mi-35 "Hinds," as well as evaluating China's Z-10.

Now U.S.-based BLR Aerospace says it has developed a compelling upgrade that could breathe new life into the world's remaining Cobra fleets.

"Some operators of the Cobras are having to make a trade-off between gas and bullets," Dave Marone, BLR's vice president for marketing, told Aviation Week at the Helitech exposition in London this month.

Marone says several operating nations are beginning to bump up against the life of their airframes but do not have the money to replace their helicopters. He suggests that BLR's upgrade could be compelling to the remaining operators facing issues with Cobra's airframe, improving the type's performance and increasing its lethality—increased payload capability allows it to carry more weaponry for longer.

BLR holds the restricted category type certificate for the AH-1 and plans to make improvements to the rotorcraft, including upgrading it with BLR's FastFin, a system already on 900 helicopters worldwide that improves anti-torque capabilities, along with strakes fitted along the tail boom to redistribute airflow around the rear of the aircraft.

Internally, the helicopter's oil-cooling system uses bleed air off the engine compressor, but this increases the temperature of the engine, pushing it closer to its thermodynamic limits. BLR plans to use an electrical system to cool the oil, which it says will help increase engine output. The rotorcraft's engine particle separation system, which also uses engine power, will be replaced by an inlet barrier filter. Marone says these changes alone could add 1,000-1,500 lb. of payload capacity in some conditions, offering an increase in endurance or weapons load.

In an unusual move, BLR is also offering to undertake structural modifications. It proposes a new load beam—what Marone calls the backbone of the helicopter—produced from new materials. Other changes that could reduce empty weight still further would include the option of a new glass cockpit with large digital, multifunction displays, he says.

BLR is so confident in the upgrade program that it is modernizing a former U.S. Army TH-1P to demonstrate it. Marone says the helicopter should be ready to fly in early 2016.

Customers could send their rotorcraft to the U.S. for modification, or BLR could modify helicopters from the boneyard and then sell them to existing AH-1 operators. BLR is also looking at a kit option that would enable customers to do some of the work in-country. The equipment will be subject to U.S. International Traffic in Arms Regulations and export controls.

Marone says the upgrade could apply to all versions of the Cobra, even the twin-engine Super Cobras in use with the U.S. Marine Corps and Taiwan, but both operators are replacing the type with the new AH-1Z Viper or the AH-64 Apache.

The upgrade likely will appeal more to operators of the single-engine versions.

The U.S. State Department has always been sensitive about sales of the Cobra. In recent years, it has vetoed transfers of the helicopter to Nigeria, which had hoped to use the type in its ongoing operations against the Boko Haram Islamic militant group. The department has also denied sales to overseas private operators that wish to display demilitarized versions of the helicopter at air shows.

In July it emerged that Israel had transferred some of its retired Cobras to the Jordanian armed forces to supplement those Jordan is using against the threat of Islamic State militants on its northern borders. Jordan has shelved plans to buy Boeing's AH-6i, citing budgetary issues, which means the Cobras may fly on for years to come.

Press Print

New industrial-scale 3-D-printing venture targets Boeing, Lockheed work

Graham Warwick Washington

NTI's wire-based plasma process produces titanium parts that require less material and machining.

NORSK TITANIUM PHOTOS

In a bold move to bring industrial-scale 3-D printing to the aerospace supply chain, Norway's Norsk Titanium (NTI) is partnering with a U.S. state to establish a facility to produce aircraft and engine components using additive manufacturing (AM).

NTI has developed a plasma-arc-based direct metal deposition technology that can produce aerospace-grade parts from titanium wire. The U.S. manufacturing facility, which will be built and owned by the state government and leased and operated by NTI, will be able to produce 1,000 tons (2 million lb.) of titanium parts a year by 2018, says President and CEO Warren Boley.

"What 3-D printing technology enables us to do is to take legacy titanium products with 55-75-week lead times and buy-to-fly ratios of 10-20 to 1, take the CAD [computer-aided design] file and print a 20-lb. part in 2 hr.," he says. "The printed part has equivalent mechanical properties—in fact, the fracture toughness and crack-growth performance is elevated, which is a future design opportunity."

With high strength and light weight, titanium is increasingly used in aerospace, but the weight ratio of raw material to finished product can be high and machining is expensive. By printing near-net parts that require less material and machining, "we can eliminate 50-75% of the cost," says Boley. NTI has provided pricing to manufacturers and is producing parts for testing, he says.

NTI estimates there are 1,000 titanium parts in a Boeing 787 that can be printed using its process. "We are already providing Boeing with pricing data. We think we can save $2,500 per part; that's $2.5 million per aircraft. At 144 aircraft a year, that's $360 million. That kind of saving is revolutionary," he says.

Savings come from "how much material goes in and how much is machined off," says Boley. "You can take a 200-lb. forging and produce a 20-lb. part. We can print 30 lb. of material to produce a 20-lb. part." Components produced require only finish machining. "It is the ultimate in lean manufacturing—wire to finished part in 150 ft.," says Chet Fuller, NTI's chief commercial officer.

While the use of additive manufacturing by the aerospace industry is growing, announcement of the location of the "government-owned, contractor-operated" (GoCo) facility in the next few weeks will "supercharge the technology," Boley says. The unnamed U.S. state will build the facility and equip it with NTI's direct metal deposition machines, then lease it to the company at an "attractive price," he says.

A Boeing 787 demonstration component shows (left to right) the part as printed, then the two machining steps required to produce the finished item.

"This is the closest thing to a Silicon Valley startup in aerospace. The GoCo partnership allows rapid introduction into commercial and defense customers, where titanium is an increasingly important aspect of their business," says Boley. "We are also talking to Lockheed Martin. There is a product and industrial cooperation opportunity, as Norway is an F-35 [Joint Strike Fighter] partner."

NTI has completed material and process qualification testing, producing 1,800 test coupons, and is submitting the data to manufacturers and the FAA for certification. "We are now into part demonstration and qualification at the specific part-number level. Manufacturers are clearly saying this is an equivalent titanium product. Now we need final approval before we can deliver parts," he says.

Boley expects to start receiving orders in first-quarter 2016, for delivery of flyable components in the second quarter. The U.S. facility is planned to be operational by the end of 2016. To meet customer certification and delivery dates, and provide a schedule buffer, NTI is adding four production machines to its test center in Norway.

In the initial phase, the U.S. plant will ramp up to 50 machines, but the facility will be able to accommodate up to 100 machines, with the capacity to produce 2,000 tons of titanium components annually. Boley says NTI's wire-fed plasma process lends itself to industrial scaling more easily than additive-manufacturing technologies using lasers or electron beams and requiring vacuum processing.

NTI's machine has a 1,000 X 500 X 300-mm (40 X 20 X 12-in.) working volume, similar to conventional machining centers used by aircraft manufacturers. Where additively manufactured components are usually compared with castings in terms of performance, Boley says parts produced are like forgings. The argon environment used allows for heating, cooling and quenching to enhance material properties versus vacuum processing, he says.

The process technology also allows the material microstructure to be tuned, so that fracture toughness can be elevated at the cost of tensile strength. In parts designed to damage-tolerance requirements, some parts leave the factory with a crack, the process can improve crack-growth resistance, Boley says.

Cleen Living

Delta TechOps-led research will support tests of an anti-erosion coating

Graham Warwick Washington

An FAA research program that has helped to mature technologies for the latest generation of commercial turbofans has broadened its scope to include demonstration of a coating technique that promises to extend the life of in-service engines.

A team of Delta TechOps and MDS Coating Technologies Corp. (MCT) is one of eight to be awarded contracts totaling $100 million under the FAA's second Continuous Lower Energy, Emissions and Noise (Cleen) research program. The others are Aurora Flight Sciences, Boeing, General Electric, Honeywell, Pratt & Whitney and UTC Aerospace Systems. They will all match or exceed the FAA funding for a total investment in the five-year Cleen 2 program of at least $200 million.

The Delta/MCT project will focus on countering extensive erosion of the fan blades on Pratt & Whitney JT8D-200s powering Delta's McDonnell Douglas MD-88s. Thought to be caused by rain cavitation, the erosion results in loss of blade leading-edge profile and chord length, says Jeff Peiter, Delta TechOps manager for enabling technologies.

"This is a high-rpm fan and it is fuselage-mounted. The erosion is more extensive than with any other engine in our fleet. This results in a significant loss of performance between overhauls and a higher fuel-burn rate," he says. "What we would like to accomplish is to reduce fuel burn and emissions with a nitride-based hard coating on the titanium blades."

The overhaul cycle on Delta Air Lines' JT8Ds is 2.5-3 years. Typically, new fan blades need to reprofiled after the first overhaul interval, and repaired or replaced after the second. "We would love to see a 100% reduction in erosion between overhauls, but we don't know if that is feasible," says Peiter. "Under Cleen 2 we will be doing testing to correlate laboratory work to the real world, to see if there is any delay in the erosion and reduction in deterioration."

Component-level testing has been performed and has shown significant improvement versus uncoated blades, says Marcio Duffles, MCT vice president for business development. These tests have taken the coating to a technology readiness level (TRL) of 5. Flights under Cleen 2 will take the technology to TRL 8-9, he says, ready for production.

Under Cleen 2, further component-level testing is planned at the U.S. Air Force Research Laboratory six to eight months after contract award, in its supersonic rain erosion rig. "It will take another year to go through the airworthiness certification steps, so it should take 1.5-2 years to get to flight," Duffles says. Delta will obtain a supplemental type certificate (STC) for the coating, enabling the airline to begin applying it to new and overhauled engines across the fleet if the Cleen 2 demo is successful.

The fan-blade treatment is the latest version of MCT's BlackGold nanostructured coating, and is described by Duffles as a "very thin metallic-ceramic matrix coating." Previous versions of BlackGold were used to coat compressor blades to reduce sand erosion in engines powering Sikorsky CH-53E helicopters and, most recently, Bell Boeing V-22 tiltrotors and Sikorsky MH-60s. Another version is used to coat high-pressure compressor blades in the CFM56-7B.

"We are working with all the original equipment manufacturers, including Pratt & Whitney on the PW1000 geared turbofan and General Electric on the CFM56-5 and -7, for factory fit," he says. "The JT8D is a great opportunity for MCT, as any turbofan engine type could benefit from the coating if the demonstration is successful on a JT8D, because of its level of severity."

Delta uses MCT's coating in its CFM56s, but the erosion of the JT8D fan blades "is uniquely different to what we see on a compressor-type blade," says Peiter. Where high-pressure compressors suffer erosion from hard particulates, the JT8D fan blades must be protected against rain cavitation. "Also, these are titanium blades, versus nickel or steel compressor blades, which is why we need to do an extensive analysis."

The Cleen 2 project has two phases: research in the lab to gather data to present an STC to the FAA; then installation of coated blades in engines that are in service and periodic inspections during use. Delta TechOps plans to inspect the blades "every couple of hundred hours," says Peiter.

Up to four aircraft will be used, and tests will involve fans with a "rainbow" of new and overhauled, coated and uncoated blades to provide the data needed to correlate with the laboratory tests and prove the technology.

DELTA AIR LINES

JT8Ds have the highest fan-blade repair and replacement rate in Delta's fleet.

Lithium Loophole

Panel looks at ways to lessen danger of 'thermal runaway' cargo fires

John Croft Washington

A loophole allows unlimited small packages of cells/batteries to be shipped in bulk without notification.

International Civil Aviation Organization (ICAO) member nations and airline safety advocates will attempt this month to legislate a safer way to transport billions of lithium-chemistry batteries by air every year. Recommendations being considered by the 20-member Dangerous Goods Panel could drastically change how the batteries are packed and shipped.

Proposals include: an outright ban on shipping lithium-ion batteries in passenger aircraft until better packaging is available, requiring airlines to complete mandatory risk assessments before transporting them, shipping at lower levels of charge than currently done and removing the so-called lithium battery "loophole" that allows for unlimited numbers of small batteries to be shipped in bulk without the typical hazardous material notifications to the airline.

The panel meets three times every two years, with October's final meeting the capstone where final agreements on new or revised technical instructions for shipping will notionally be approved and set for implementation Jan. 1, 2017.

The need for change has been highlighted by at least two cargo aircraft losses where bulk shipments of individual lithium batteries or cells were implicated—a UPS DC-8 freighter in Philadelphia in 2006 and a fatal UPS Boeing 747-400 freighter crash at Dubai in September 2010—and by a growing portfolio of battery testing results by the FAA at its Atlantic City International Airport Technical Center in New Jersey. Researchers there have shown that fires in bulk shipments of lithium-metal batteries—the nonrechargeable batteries used in cameras, watches and other consumer electronics—cannot be extinguished by the Halon fire suppressant used in aircraft cargo holds, and that the same suppressant is only "marginally effective" in putting out lithium-ion battery fires. The situation is worse for freighter aircraft with "Class E" main deck cargo areas that generally have no active fire suppressant.

The failure mechanism for both chemistries typically starts with the "thermal runaway" of a single cell, which can be caused by damage, heat, overcharging, undercharging or other factors. Once a cell vents, spewing flammable electrolytes at temperatures above 1,100F, the adjacent cells then follow suit and the packaging, typically a cardboard box that ignites at 400-500F, becomes engulfed in flames.

The FAA used as many as 5,000 lithium-ion cells in bulk (and 4,800 lithium-metal cells) for testing, but actual cargo loads can contain 50,000 cells or more. Even when fire suppressant dampens flames, the FAA has shown that gases released by only a handful of batteries in thermal runaway can accumulate and cause a blast that can destroy a cargo container. The agency also demonstrated that a 30% state of charge (compared to the 50% at which batteries are normally shipped) will limit thermal runaway between cells, a finding fueling proposals to limit the charge levels of the batteries before shipment.

Pilots flying the cargo may not be aware of the actual threat level, thanks to the unintended consequences of an ICAO 2012 rule change relaxing controls for small shipments of the same types of small lithium batteries the FAA tested. Section II of the technical instructions for shipping dangerous goods allows shippers to package two batteries (100 Wh maximum energy for lithium-ion batteries) or eight individual cells (20 Wh maximum each for lithium-ion cell) in approved packaging that meets drop test and other requirements—but without the more rigorous documentation, employee training and other requirements needed to transport dangerous goods. Section II is often referred to as the "lithium loophole."

"Unfortunately, what's happening is that shippers are overpacking the Section II shipments," says first officer Mark Rogers, Dangerous Goods Committee chairman for the International Federation of Air Line Pilots Associations (Ifalpa). "They'll take a small cardboard box with eight cells, then put many of those boxes together in a larger box [an overpack] and put those boxes together in a high-density pallet."

Michael Moody, Jr., a UPS captain and chairman of the Independent Pilots Association (IPA) safety committee, says there could be "hundreds, and even thousands of batteries" within the larger overpack box. IPA is the union representing UPS pilots. "Section II packages do not require any notification or declaration. In other words, the pilot has no idea that they are on board the aircraft," says Moody, adding that even airlines that state they are voluntarily refusing to transport lithium batteries may not be aware they are carrying Section II cargo unless they visually search every package, since there is no paperwork to consult.

Ifalpa has four main proposals for the Dangerous Goods Panel, of which it is a member. Some overlap with the 14 recommendations for a multilayered safety net crafted by ICAO's government and industry Multidisciplinary Working Group over the past two years. Among them is a call for improved cargo safety standards for freighters (possibly including fire-resistant containers and pallet covers or a reduction in the number of cells or batteries allowed to be carried on the aircraft or in specific compartment) a request to eliminate Section II and a proposal to create a performance-based packaging standard that will define the criteria and processes a shipper can use to demonstrate that packaging is able to contain a thermal runaway. Detailed performance standards could include a requirement that no flames or fragments exit the package or that certain temperature limits are not exceeded. However, Rogers says such a standard is several years from reality, making it essential that lithium-ion batteries be prohibited from passenger aircraft in the interim.

"The ultimate solution is packaging that will ensure that a shipper determines the safe number of batteries in the

package in order to meet the standard that no hazardous effects of a fire can be seen outside the package," he says. "Until that standard is in place, we have no real ability to determine a safe number of batteries, and we do not have the ability in the current regulatory scheme to limit the number of packages in the cargo compartment or on the aircraft."

UPS, which has been hit harder than most in the industry, is being proactive. Working with the IPA, the carrier has deployed fire-resistant package containers for lithium batteries, fire-containment covers for cargo pallets (in Class E areas) and new safety equipment in the cockpit, including Emergency Vision Assurance Systems (EVAS) for cockpits. An EVAS is an airbag that inflates when the cockpit fills with smoke, allowing pilots to see through the windscreen. UPS continues to research enhanced fire-resistant containers, most recently developing a system that can reduce the potential for explosion when melting lithium batteries produce combustible gases. FedEx's approach has been to deploy an aircraft-mounted fire suppression system for Class E cargo areas on all its widebody freighters.

Intervention is also taking place at the packaging level. Underwriters Laboratories, which became the NTSB's go-to organization in 2013 for researching the failure mechanisms in the eight-cell main and backup lithium-ion batteries in the Boeing 787, says spacing of at least 2 mm (0.08 in.) between cells in a battery minimizes the chance for thermal runaway. But it says, "the proper method of minimizing the chance of thermal runaway propagation varies significantly with cell type and module configuration." Boeing solved its 787 battery issues by providing more isolation between cells and making changes to the battery case, including a dedicated vent line to the outside of the aircraft.

AkroFire, a Kansas company that provides cargo container repair kits and shipping boxes for oxygen generators, has developed a "loose fill" packaging solution using "packing nuts" designed to fuse together and form a rigid protective barrier around batteries or cells when exposed to internally or externally generated heat or fire. President Jon Green says the Pyro Pax concept, which requires about 2 in. of spacing around the batteries or cells to be filled with the packing nuts, is aimed at smaller shipments of damaged or defective batteries but might also be a solution for an overpack shipment. During testing with as many as 300 CR123 lithium-metal cells triggered into a thermal runaway, Green says external temperatures on the cardboard box remained at approximately 200F, well below the ignition point for cardboard, while internal temperatures soared to nearly 2,000F as thermal runaway spread to all of the cells.

High Hopes

Inspiration, scientific data and an altitude record motivate the Airbus Perlan Mission II team

Perlan 2 separates after being towed to 5,000 ft. altitude for its first flight.

AIRBUS GROUP

Graham Warwick Washington

Their inspiration may be to fly higher, without an engine, than the iconic Lockheed U-2 and SR-71, but an Airbus Group-supported team hopes flights to 90,000 ft. with the Perlan 2 glider will contribute to aeronautical and atmospheric research.

The pressurized two-seat glider made its first flight on Sept. 23 from Redmond, Oregon, where it was built by experimental aircraft specialist RDD Enterprises. In 2016, the Perlan 2 will be moved to Argentina, where its crew will attempt to ride mountain waves and the polar night jet stream into the stratosphere and the record books.

Airbus Perlan Mission II is a follow-on to the original Perlan Project flights, which culminated in adventurer Steve Fossett and research pilot Einar Enevoldson setting a glider altitude record of 50,721 ft. in August 2006. Where the first aircraft was a modified Glaser-Dirks DG-500 sailplane, Perlan 2 has been specifically designed for high-altitude flight.

In addition to exploring aircraft performance at high altitudes, the team plans to collect atmospheric data to improve the models used to forecast weather and predict climate change. "The project's goals are: aeronautical exploration, to understand aircraft dynamics at high altitude; meteorological research at 60,000-90,000 ft., a region that is not well understood; and to be an inspirational, science-based mission," says board member Stephane Fymat.

The inspiration and education part of the mission interests Airbus. "We want to stimulate thinking by young people about aviation and exploration, so they become future employees," says Allan McArtor, chairman and CEO of Airbus Group Inc. Additionally, conditions at 90,000 ft. mimic the atmosphere of Mars, which is of value to the European giant's space engineers "although we don't have a Mars plane on the drawing board," he says. The company is developing high-altitude pseudo satellites, such as the Zephyr unmanned aircraft that can fly above 70,000 ft. to provide communications and surveillance.

Enevoldson, who set powered-aircraft altitude records in the Grob Egrett and Strato 2C, initiated the Perlan Project in 1992 after seeing lidar images of stratospheric mountain waves at German aerospace center DLR. Fossett funded a small team to prove a glider could soar to high altitudes using those waves. "When they set the record, they were still going up," says Fymat. "They only came down because their pressure suits had inflated, and they could not move their arms to control the aircraft."

Fossett proposed building a special-purpose sailplane, but died in 2007 and the project slowed. It picked up pace in 2009 when new donors came on board. Airbus joined as title sponsor in 2014. Although it entered the project after the Perlan 2 had been designed, "Airbus has provided much more than just financial support," says chief pilot Jim Payne. "The few times we have needed engineering and technical help, Airbus has stepped up." That has included assistance with patenting the design.

"We were able to look over their shoulders and review their design and certification strategies. It has been a verification role," says McArtor. "We put up some money to build the glider and offered our expertise to verify their modeling and manufacturing. In return we get the ability to measure the atmosphere at high altitudes. In the next 10-40 years, we will see flights into the stratosphere—whether subsonic or hypersonic—so we need to know more about it."

The aircraft is similar in design to open-class sailplanes, but where they

are designed for speed, Perlan 2 is optimized for climb performance, low sink rate and flight at low Reynolds number at high altitude, says Payne. The airfoil is optimized for 60,000 ft., where the climb rate is lowest. At 84 ft., wing span is the same as an open-class sailplane, but the chord is longer and loading is lower for better climb performance.

The aircraft is pressurized to a cabin altitude of 14,500 ft.; the need for round windows for maximum strength at minimum weight gives the carbon-fiber Perlan 2 a look similar to Scaled Composites' suborbital SpaceShipOne. The cockpit is designed to minimize leaks, and air is added from scuba tanks to maintain cabin altitude up to a maximum pressure differential of 8.5 psi.

At 14,000 ft. the crew will go onto supplemental oxygen using a rebreather system that removes carbon dioxide and allows unused oxygen to be recycled. The closed-loop system will not introduce any extra oxygen into the cabin atmosphere, "so we will not have to worry about fire," says Payne. Breathing 100% oxygen will provide the crew with some resistance to sudden decompression, he adds.

In an emergency, a drogue chute deployed from the tail will limit speed in a dive to the equivalent of 81 kt. "At high altitude, we will get a very rapid descent—at 90,000 ft., 1 kt. indicated airspeed equals 6 kt. true airspeed," says Payne. The dual-redundant drogue chute will be tested only on the ground, as will the ballistic airframe recovery parachute for use at lower altitude.

For its first flight, the Perlan 2 was towed to 5,000 ft. above ground level at Redmond and released so pilots Payne and Morgan Sandercock could conduct basic handling-quality tests. "It flies like a big open-class sailplane," says Payne. "It is very stable in pitch, will not roll fast and has slightly high stick forces, which is pretty much as we expected."

The flight was also used to check visibility through the porthole-like windows. Prior to the first flight, a couple of towed flights were made in sponsor Dennis Tito's DG-1001 sailplane, which was modified with paper to simulate the Perlan 2 windows. "With the window arrangement we [lose the] visibility of a sailplane, but it is more than adequate for the mission," Payne says.

Following the first flight, Perlan 2 has gone back to RDD to complete installation of the pressurization and oxygen systems. The aircraft will then be moved to San Diego for ground vibration testing; it is expected to fly again in December at Minden, Nevada. There the crew will begin to fly in mountain waves, increasing the altitude in steps. McArtor says Airbus people are likely to participate.

"The schedule is at the mercy of the weather, but from February to May [2016] we plan to fly at Minden in waves up to 40,000 ft. to verify the pressurization and rebreather systems," says Payne. The team plans to relocate to El Calafate in Patagonia, Argentina, in late June and attempt to set the 90,000-ft. alt. record during the Southern Hemisphere's winter—July-October.

El Calafate, where Fossett and Enevoldson set the existing record in Perlan, was chosen because soaring to such high altitudes requires the combination of two atmospheric phenomena—not just stratospheric mountain waves, but also the polar-night jet stream, which forms in winter at the circumference of the polar vortex. Steadier around the South Pole, the night jet adds energy to the mountain waves and allows them to reach higher altitudes. "To reach 90,000 ft., the wind needs to blow stronger as we go higher in altitude or the waves collapse," says Ed Warnock, CEO of the Perlan Project.

After takeoff from El Calafate, Perlan 2 will be towed some 50 km (30 mi.) to where mountain waves are expected. Payne says the team will use numerical models to predict where waves will be—and how long they will last. "A wave is a relatively long event, involving large-scale weather. A good wave will last 3-4 days; we are planning an 8-hr. mission," he says. The glider will climb at up to 1,000 ft./min, but descend more slowly.

The crew expects to fly at 38-40 kt. indicated airspeed, but true airspeed and wind speed will be much higher and likely close in value. "We will point into the wind and station-keep as we go up like an elevator," says Payne. At lower latitudes, true airspeed will be higher than wind speed, so the aircraft will zigzag to stay within safe airspace as it follows the line of lift along the mountains.

Payne, with more than 1,500 hr. experience flying gliders in mountain waves, says they are usually located visually. "Lenticular clouds mark the leading edge of the waves. We will use that initially, then use the variometer [climb/descent speed indicator] to find the best position in the wave and our computer track on the map display to stay in a safe spot," he says. At high altitude, stall speed and never-exceed speed will be close together, but Perlan 2 is manually flown. There is no autopilot, only a yaw damper for operation at high altitude.

A science bay is in the cabin for payloads. The plan is to collect aircraft and atmospheric data over multiple high-altitude flights. "Early missions will be limited to a lightweight package. As we get more experience, it will get heavier and more robust," says Warnock. Research will be focused on weather forecasting and ozone depletion.

"All climate models assume the troposphere and stratosphere do not mix, but we now know that is not true. Our flights will help us understand the mixing and provide empirical data to improve the models," Warnock says. Mixing is caused by the interaction of mountain waves with the polar vortex, "and we want to know what that does to the ozone layer and ozone hole," McArtor says.

The glider will be able to take uncontaminated air samples to measure chemicals and particulates at high altitudes "to see if we are slowing or reversing ozone depletion," says Warnock. Stratospheric mountain waves connect to the ozone layer and may contribute to the formation of nitric acid crystals that come in contact with chlorofluorocarbons in the atmosphere, causing the release of chlorine that catalyzes ozone destruction, he says, adding, "The ozone hole grows when waves are active. We will be able to study the chemistry of ozone depletion in real time."

With plans for multiple flights to high altitude, the Perlan Project has funding for two flight campaigns in Argentina, in 2016 and 2017. "Our goal is to get to 90,000 ft., but we plan to continue the project," says Warnock. "We would like eventually to go to high altitude in the Northern Hemisphere, over Norway and Sweden, to conduct the same type of research."

But the lasting contribution could be in changing the perception of what is required to reach the stratosphere. "The paradigm has been that more altitude equals more power. Enevoldson had a background in high-altitude powered flight and in soaring, and he saw a new paradigm," Warnock says. "We will break the world altitude record for sustained level flight and do it without an engine. And we can stay at 90,000 ft. as long as the wave is there."

TONY OSBORNE/AW&ST

Agony of Choice

Britain needs airborne maritime surveillance, and industry wants a piece of the action

Tony Osborne London

With the U.K.'s Strategic Defense and Security Review (SDSR) set to be published in November, industry is preparing to meet the big gap in airborne maritime surveillance left by the cancellation of the Nimrod MRA4 program in 2010.

It seems almost certain that the SDSR will detail a need—but not necessarily a requirement—for a multimission platform able to take on what the head of the U.K. Royal Air Force, Air Chief Marshal Andrew Pulford, described at the London DSEi defense exposition in September as a "persistent wide-area surveillance over land and over water" mission. And industry is working hard to push for a competition.

Britain's Nimrod force ended up taking on a overland surveillance mission in its twilight years.

Britain lost its maritime patrol capability in 2009 when it retired its Nimrod MR2 fleet over airworthiness concerns, while the 2010 SDSR canceled the MR2's replacement, the Nimrod MRA4 program, which was years behind schedule and hundreds of millions of pounds over budget.

But with the Russian bear acting more aggressively and the U.K. investing billions into new carrier capabilities and a new-generation submarine-launched nuclear deterrent, Britain will need to purchase a multimission/maritime patrol aircraft (MMA/MPA) in order to protect its investment.

Several companies have revealed their potential solutions for this need, but there are concerns in industry that Boeing's P-8 Poseidon may still have an edge.

"It is P-8 or a competition," said one senior British officer at a maritime reconnaissance conference in London in late September. "Much of [the decision] depends on how quickly we need it."

One could argue that moment has passed. As first reported by Aviation Week in November 2014, Britain faced

international embarrassment when it had to call on Canadian, French and U.S. allies to help it hunt a submarine off Scotland's western shores.

Boeing apparently made an offer last summer to sell P-8s to the U.K., but the deal fell through when it was reviewed by Defense Secretary Michael Fallon. There remains considerable interest in the platform, however, thanks in part to the significant role being played by British personnel in Project Seedcorn, the U.K.'s bid to retain experience in anti-submarine and anti-surface warfare.

But there are several significant concerns about P-8. The first is its considerable cost: It is the most expensive solution now available. Senior officers are also concerned about the readiness of the aircraft's overland surveillance capability, which is restricted to the electro-optical sensor capability. A wide-area surveillance capability will be developed for use in the early 2020s, but it is unclear whether Britain will be able to access it.

There are also concerns about whether the U.K. would be able to use its own air-dropped torpedo, Stingray and locally developed sonobuoys. Integration of such systems would likely require more funding than the U.K. has.

U.S. Navy officials told Aviation Week at a conference in London in late September that if the U.K. wants P-8s before 2020, it will have to make a decision relatively soon. Boeing is already negotiating Lot 7 advanced procurement with the U.S. Navy, so Britain will have to consider entry into Lot 7 or Lot 8.

They also warned that the U.K. faces losing a generation of experienced personnel if it waits too long to regenerate the capability.

Despite the Conservative government announcement that it will maintain defense spending at 2% of gross domestic product for the lifetime of the current Parliament, it remains unclear where the funding for the platform will come from—or indeed how many could be purchased. Before the order was canceled, the U.K. was planning to buy just nine Nimrod MRA4s. Given the high tempo of operations by British intelligence, surveillance and reconnaissance aircraft (ISR), many industry figures suggest nine aircraft would not be enough to meet U.K. needs.

Airbus Defense and Space officials have said that the U.K. purchase of an MMA/MPA represents a last chance for U.K. industry to be involved in a British ISR aircraft program. All the other fixed-wing ISR aircraft in use heavily feature equipment from U.S. primes, such as Raytheon's Sentinel radar-reconnaissance aircraft or Boeing's RC-135 Rivet Joints with equipment from L-3 Communications.

"There has to be a competition," said Nicholas "Flash" Gordon, director of international programs at L-3, speaking at DSEi. "When you listen to [Fallon] here at DSEi, and he talks about the prosperity agenda, exportability and investment in U.K. industry, . . . this is more to do with capability than the platform."

Fallon says U.K. defense would tap into small- and medium-sized businesses and make additional pushes for export success. Many companies offering a solution for a U.K. MMA/MPA are advocating either a significant British equipment presence in their platform, or a U.K. role in the integration; others plan to offer both.

The need for such a competition has been endorsed by several think tanks. The London-based Royal United Services Institute (RUSI) noted there had been a great deal of admiration from the Royal Air Force for the P-8.

"The subtext was clear," say RUSI research fellows John Louth and Peter Roberts. "If the government was going to reinvest in an MPA capability, why not buy the P-8 off the shelf? A quick purchase offers an immediate utility, whereas the delay associated with a competition would merely extend the life of the capability gap."

Louth and Roberts urge, however, that the SDSR call for the "reinstatement of a necessary capability and a commercial competition," and "not the announcement of the imminent arrival of a purchased aircraft."

In May, a report from the liberal think tank CentreForum stated there is no justification for a sole-source P-8 procurement. Report author Toby Fenwick argues that if the U.K. Defense Ministry wants such a capability in a hurry, it should issue a requirement as soon as it is ready. "This would allow industry to be well-placed to respond in a competition in 2015-16," he writes.

Airbus Defense and Space and Finmeccanica's Alenia Aermacchi have responded with conversions of their twin turboprop transports, the C295 and C-27J Spartan, respectively. Both companies believe their options offer low-cost operation. They also think adopting a roll-on/roll-off mission system could allow the platforms to be used for special forces operations, fitting into a perceived airlift gap between the Airbus A400M and CH-47 Chinook when the C-130J Hercules retires in 2022. Airbus Defense and Space officials, however, claim an MPA version of the C295 with U.K. equipment and sensors would be "as good as, if not better than the Nimrod MRA4."

Lockheed Martin plans to offer to convert some U.K. C-130Js into SC-130J sea versions with a U.K.-sourced mission system and sensor suite. L-3 has partnered with Selex ES and Ultra Electronics to offer a Bombardier Q400-based solution. The aircraft would be fitted with pannier-like fuel tanks on the side of the fuselage to increase endurance and a canoe fairing to carry weaponry and sensors underneath. Another option is Japan's indigenous four-engine Kawasaki P-1.

The U.K. could be spoiled for choice when it comes to hunting for a new multimission aircraft, with the Boeing P-8 and Kawasaki P-1 in the frame.

GLENN WHEELER/HIGHCAMERA LTD./RIAT PHOTO TEAM

Stovl Shipmates

U.S. jets will be needed to exploit British carrier capabilities

Bill Sweetman and Tony Osborne London

Senior officers in both the U.S. Marine Corps and British Royal Navy agree that Marine Corps Lockheed Martin F-35B Joint Strike Fighters (JSF) will operate regularly from the Royal Navy's new aircraft carriers, HMS Queen Elizabeth and HMS Prince of Wales. The question is how many fighters and when, and it appears to be a sensitive issue due to the impending release of the U.K.'s Strategic Defense and Security Review (SDSR).

One option under study is to attach a Marine F-35B squadron full-time to the U.K. carrier force, alongside the two planned British squadrons, according to a source close to the U.S. Navy aviation community. While senior officers say it is much too early to focus on any one joint-force structure, they acknowledge many options are being considered, and the Marines specifically identify the British ships as potential bases in their most recent aviation plan.

Shelters ringing the deck of HMS Queen Elizabeth, under construction at Rosyth, Scotland, cover rework necessitated by higher-than-predicted exhaust velocity and temperature from the F-35B.

AIRCRAFT CARRIER ALLIANCE

The SDSR is expected to clarify two related issues. First, the U.K. has committed to buying 48 JSFs between now and the early 2020s but has not set any time frame for further orders: Its original plan was to buy 138 F-35s. Second, the British government in 2014 reversed its decision (in the 2010 SDSR) to mothball or sell one of the carriers but has not said whether both will sail full-time or they will operate on an overlapping cycle that keeps one ship available at all times. But the 48-aircraft force is expected, at best, to generate only one "maximum effort exercise" every other year with 24 embarked jets, while the carriers were designed to support 36 F-35s each, full-time.

The question is how the SDSR deals with this gap. The issue "is sensitive because numbers are being discussed in the SDSR," says a British officer. Publicly, the Royal Navy likely wishes to avoid the perception that its flagships are providing support to the Marine Corps, while the U.S. Navy big-carrier community may look askance at the Marines' new $145 million aircraft filling Royal Navy decks in the 2020s as the U.S. Navy depends on rebuilt Super Hornets to maintain its carrier air wings.

The Marines have the opposite problem from the U.K.: They plan to acquire 353 F-35Bs, but the only U.S. Navy decks available to them in the 2020s will be 11 LHD Wasp- and LHA America-class ships that normally carry six fighters each. In 2013, Lt. Gen. Robert Schmidle, then-Marine Corps commandant for aviation, said the Corps' F-35s would fly short-takeoff, vertical-landing (Stovl) sorties on "a small percentage" of missions. As a result, the Marines appear eager to share the new British carriers as a way of building and sustaining shipboard experience.

The need for Marine assets to make full use of the carriers will depend on several factors, including how many aircraft the U.K. can generate sustainably. Royal Navy officers are unwilling to state how many aircraft will be at sea at any time, saying only that the ships will have the "largest practical" air wing.

One factor that may mitigate the shortage of British F-35s is that the U.K., with military planning increasingly influenced by U.S. Joint Forces Command, is moving toward a broader mission for the carriers in which they carry more than F-35s and supporting aircraft. Their role is now defined as "carrier-enabled power projection" or CEPP, according to Rear Adm. Simon Blount, assistant chief of the British naval staff and senior responsible owner for the Queen Elizabeth class. Speaking at the DSEi show in London in September, Blount said CEPP "is not a term with a long history. Carrier strike is the term people understand."

At one end of the CEPP spectrum is carrier strike, with the ship dedicated to air warfare and carrying F-35Bs, supported by two versions of the Merlin HM2 helicopter: Crowsnest airborne early warning and control platforms and standard-fit HM2s for force protection against submarines and other threats.

The other end of CEPP is littoral maneuver, carrying two companies of heliborne assault troops supported by CH-47 Chinooks, Merlin assault transports and AH-64 Apache and AgustaWestland Wildcat scout and attack helicopters. Between the two roles is "expeditionary strike" with F-35Bs and a Royal Marine commando.

On Blount's chart, the carrier strike F-35 force—the largest in any of the mixes—is described as "U.K. plus allied mix." Blount says this is nothing unusual. "We expect to plug-and-play with coalition forces—this is the way wars are fought today," Blount tells Aviation Week. "We expect the Marines to be aboard the Queen Elizabeth class, to get the most bang for the buck."

Blount says it is too soon to expect firm details of the Marines' involvement. "I talk to [Marine deputy commandant for aviation, Lt. Gen. Jon] Davis all the time. He's interested in our carriers,

Request for Proposal

SAUDIA is pleased to announce its requirement for a number of wide body aircraft for Umrah & Hajj operations 1437H corresponding to 2016 from IOSA Certified Operators on ACMI wet lease basis in accordance with following terms and conditions:

- Lease term from 21 Rabi Awaal 1437 H to 02 Rabi AlThani 1438 H Corresponding to 01 January 2016 to 31 December 2016.
- Seats configuration: minimum 300 seats.
- Minimum seat pitch 30 inch.
- MGH 2200 BHrs for the entire lease period per unit.
- If Umrah only; 1400 BHs per unit.
- If Hajj only; 650 BHs and 750 BHs depending on aircraft type.
- Cycle ratio 3 to 1 and 4 to 1 depending on aircraft type.
- MFD must not be earlier than 1997.
- Operating base at JED – KSA.
- Deployment: Mainly Iran, Algiers, Turkey, Indian sub-continent, Far East, ME, Gulf & Europe.

Please quote your ACMI rate, which shall include the following cost parameters:

- 5 set of crew.
- Aircraft marshaling at the base.
- Hull & third party insurance covering the lease term.
- Aircraft should have functioning audio & video entertainment system
- Aircraft in white fuselage with SAUDIA (standard) letterings on both sides and logo on the tail (decals);
- Aircraft delivery/re-positioning cost (excluding fuel for repositioning flight)
- Crew hotel accommodation, transportation at the base (JED).
- Crew salaries, per diem, social cost, license insurance, Iqama (Residence Permit) fees whenever required by Saudi Government, etc.

Contestants shall submit commercial offers along with aircraft specifications/documents. Fuel burn data and technical dispatch with base stock engineering support undertakings.

P.S.

- Deadline for receiving offers is 15 days from publishing date; offers received beyond target date may not be considered.
- No commitments or agreement shall be concluded unless the lessor and its aircraft are accepted by SAUDIA Maintenance/ Flt. Ops. Standards and Quality and GACA
- SAUDIA reserves its right to accept or reject any or all proposals at its sole discretion without stating any reasons of whatsoever nature, which shall not be challenged before any authority or court of law.

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السعودية SAUDIA SKYTEAM

and I'm interested in Wasps. But given where this capability is, in terms of development, there's no memorandum of understanding, or anything like that."

Blount demurred when asked directly whether the U.K.'s 48 F-35Bs will sustain a full carrier-strike air wing, on the grounds that the SDSR will address numbers. "These ships are being built for 50 years, and the types and numbers of aircraft will change," he says. "Over the course of their lives, you will see them bristling with jets." However, the U.K. Defense Ministry said in August 2014 that it plans to stage a "maximum-effort" carrier-based deployment of 24 F-35Bs once every two years as part of its carrier-generation cycle.

Davis was similarly noncommittal at a Center for Strategic and International Studies meeting in Washington in August 2015. However, his 2014 Marine Aviation Plan's core concept of "distributed Stovl operations" envisages that small F-35B detachments at improvised land bases will have "scheduled aircraft maintenance conducted on sea base—LHA, LHD or a coalition carrier, such as the U.K.'s Queen Elizabeth II."

A British officer closely involved in the F-35B program acknowledges if the navy wants to "stretch the deck"—test the carrier's ability to support its full design complement of aircraft—it will have to involve the Marines, because the U.K.'s 48 aircraft will not sustain an air wing of more than 30 aircraft for even a short test. But that test is not firmly on the schedule yet and is described by the Royal Air Force as "aspirational."

The end-state for the U.K.'s carrier force is to have one carrier available for the full CEPP spectrum at all times. Initial operational capability with F-35Bs on board is set for 2020. Full operational capability, with one carrier available for any CEPP mission at all times, and including Crowsnest and new F-35B weapons, is not expected until 2026.

In another step toward operational capability, the U.K. Defense Ministry announced selection of the Thales Crowsnest solution to the carrier's airborne early warning and control requirement in late May. The Thales offer comprises an upgraded version of its Searchwater 2000 radar and Cerberus mission system, installed on the Merlin helicopter. Crowsnest replaces the Sea King ASaC7, which is being kept in service until 2018 rather than retired with the rest of the Sea King fleet in March 2016.

Thales has retained the inflatable dome, or "bag," as Royal Navy operators refer to it. This dome is attached to a specially designed lid, fitted to the weapons pylon of the Merlin. On the ground, the system is folded against the fuselage by electric motors. But once in the air, the hinge is lowered into the vertical position, and the bag is inflated to allow the radar to function, clear of obstructions underneath the Merlin.

Lockheed Martin and AgustaWestland have upgraded 24 of the Royal Navy's 30 anti-submarine warfare Merlins and bought them up to Mk. 2 standard through the £807 million ($1.25 billion) Merlin Capability Sustainment Program. The U.K. Defense Ministry declared the Merlin Mk.2 fleet as having full operational capability on Sept. 15 during the DSEi show.

Under the Crowsnest plan, all 30 of the AgustaWestland Merlin HM2s will be fitted to carry the system with minimal modifications. Ten system sets will be purchased and up to eight Merlins fitted out for the mission at any one time. Ministers accelerated the Crowsnest program in 2013 with the aim of bringing it into operation in 2020, rather than 2022, as originally envisaged.

THALES

Thales will provide an upgraded version of its Cerberus airborne early warning and control system, installed on the Merlin HM2, to meet the Crowsnest requirement.

Meanwhile, construction of Britain's 65,000-ton carriers is on or close to schedule, an important achievement given that they are the largest warships ever built in Britain and—except for U.S. carriers—among the world's largest.

The Queen Elizabeth has started test-running its Wartsila diesel generators at the dockside in Rosyth, Scotland, according to Aircraft Carrier Alliance Managing Director Ian Booth, speaking at the DSEi show. The ships have two Rolls-Royce MT30 engines and four diesels, all providing electric power to four electric motors. "Optimistically, she could depart from Rosyth for sea trials in late 2016," Booth says. "But in reality, it's more like early 2017."

The next year will be taken up with tests of the ship's mechanical and electronic subsystems, Booth says. One unique feature, Babcock's Highly Mechanized Weapons Handling System, is working out well, he notes. It is an automated handling and conveyor system that extracts weapons from the ship's four magazines and delivers them to the flight deck. "It's a sturdy, robust system," says Booth, based on land-based materials-handling equipment but developed using a large rig that simulated ship movements.

The carrier's deck is currently ringed with tentlike shelters as workers apply heat-resistant coatings to catwalks and install heat shields over life rafts to protect them from the blast and heat from JSF vertical landings. Booth says the carrier team is working on ways to apply heat-resistant nonskid coatings evenly to the entire deck, rather than just treating landing spots, which is not expected to be adequate for sustained operations.

Like the U.S. Navy, the U.K. carrier team did not anticipate the challenges posed by the F-35's exhaust, which Lockheed Martin maintained through 2010 would be no hotter on the deck than that of the Harrier. For the U.K., however, the problem was compounded because in 2010-12 the plan was to use the catapult-arrest F-35C. "That cost me two years of work on the heat issue," Booth says.

The Prince of Wales is being assembled and should be floated out of its dock in 2017. Work is on or ahead of schedule, Booth says, and modules for the newer ship are being delivered with more systems installed than was the case for Queen Elizabeth.

Royal Navy sailors will begin training on the ship in May 2016, with sea trials due to be undertaken in August 2016. Acceptance should occur in May 2017, and the service hopes the first F-35Bs could be landing on the vast 4.5-acre flight deck, somewhere off the U.S. East Coast, toward the end of 2018.

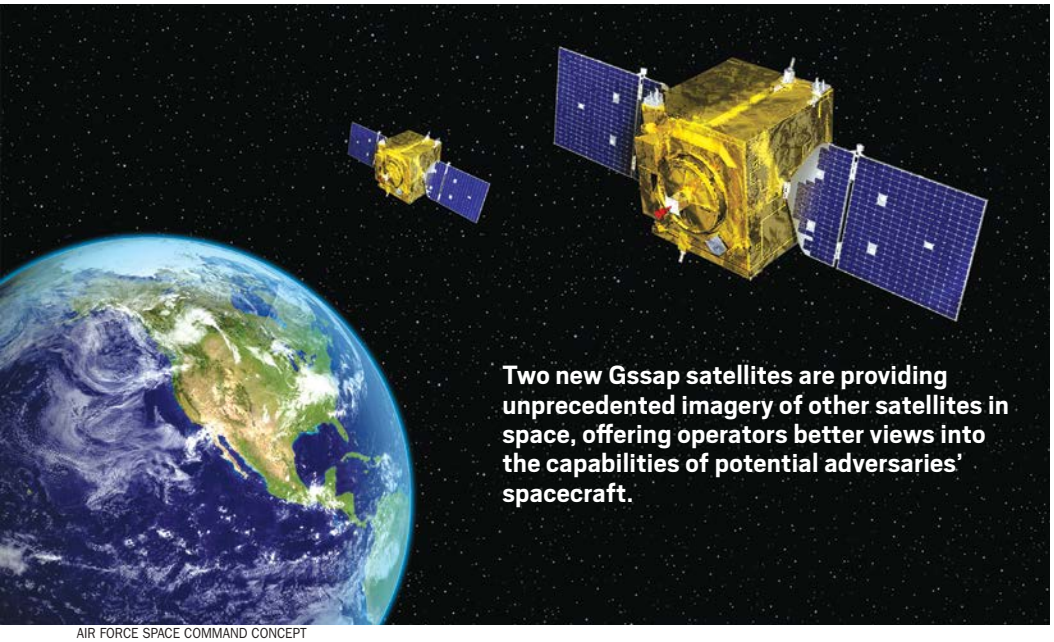
Space Moves

With more nations in play, U.S. Air Force shores up doctrine for dealing with threats in space

Amy Butler Washington and Huntsville, Alabama

Eight years after China's first anti-satellite demonstration—knocking its own aging weather satellite out of orbit with a missile—the U.S. defense and intelligence communities are finally taking action to position their space-based forces for a world in which superiority in space can no longer be taken for granted.

Since that June 11, 2007, demonstration, China has conducted more tests, with some of these indicating ambitions to threaten U.S. assets in geosynchronous orbit, including precious early missile-warning and defense communications satellites, as well as commercial constellations. The writing is on the wall: U.S. satellites no longer enjoy sanctuary in space. They are threatened by kinetic means as well as by jamming and interference. Much concerned rhetoric has flowed from the Pentagon, but until recently most initiatives to shore up the U.S. footing in space were either nonexistent or classified.



Two new Gssap satellites are providing unprecedented imagery of other satellites in space, offering operators better views into the capabilities of potential adversaries' spacecraft.

AIR FORCE SPACE COMMAND CONCEPT

In the past few months, however, the Pentagon and the intelligence community have made strides toward "operationalizing" space in a new way, posturing satellite operators to better deal with working in a contested space environment and planning to procure systems needed to provide assured command and control over U.S. assets in space. Deputy Defense Secretary Bob Work noted this during a key speech at the Geoint Symposium June 23 in Washington, saying: "Many countries, including Russia and China, have studied our way of warfighting and they search for gaps that they can exploit in the unlikely event that we would . . . have a clash of arms. And they have focused on our space system as a potentially vulnerable center of gravity for U.S. military power—and they are right. . . . As a result, space must now be considered a contested operational domain, in ways that we haven't had to think about in the past. Said another way, we find ourselves dependent now on space capabilities that are increasingly vulnerable to counterspace systems that others are developing."

He outlined a need for better coordination among the Pentagon and the intelligence community; the National Reconnaissance Office operates intelligence satellites separately from the Defense Department.

Plans to address this situation are finally starting to gel, or at the very least U.S. officials are touting them publicly to send a message to would-be adversaries.

A new Defense Department and intelligence community experimentation center is now embarking on an unprecedented mission to map out U.S. vulnerabilities in space, craft tactics to deal with attacks on spaceborne assets and forge recommendations for shoring up domestic space capabilities.

The Joint Interagency Combined Space Operations Center (JICSpOC) began its experimentation phase Oct. 1, kicking off nine months of trials. The JICSpOC, located at Schriever AFB, Colorado, is not to be confused with the Joint Space Operations Center (JSpOC) at Vandenberg AFB, California, an operational center that monitors all observable objects orbiting Earth and warns operators of possible collisions. The JSpOC will remain operational and continue this mission, but senior Pentagon leaders have long said its systems are limited in their ability to determine what these satellites are doing. Operators there generally track objects—or dots representing satellites or debris—but they lack intelligence on the capabilities of those objects. As a result, they are often flying blind.

This is because systems providing input to the JSpOC—terrestrial telescopes and spaceborne assets—largely lack the fidelity to do so. That is changing with the launch of two Geosynchronous Space Situational Awareness Program (Gssap) satellites capable of collecting electro-optical images of vehicles in orbit—and thus providing far more intelligence on their payloads than has been available before. And Lockheed Martin is crafting a new, improved Space Fence that will detect smaller objects. But operators still lack the doctrine to act on this data, especially at critical times when a satellite experiences an anomaly and they must quickly determine if it is due to a mechanical issue, natural phenomenon or hostile interference.

With the JICSpOC, leaders from U.S. Strategic Command (Stratcom),

U.S. Air Force Space Command and the intelligence community plan to challenge operators in an experimental environment to craft improved tactics for operating in contested space, much the way aviators experiment in Air Force-led Red Flag exercises. They will develop the doctrine governing how to deal with such instances of interference. Through this testing, they plan to expose U.S. vulnerabilities and craft solutions—or, possibly, new programs—to address them.

The trials will challenge the entire architecture—from terrestrial systems, to command-and-control links, to the satellites themselves. The JICSpOC "is focused for the next year on experimenting against different threat scenarios," said Air Force Space Command chief Gen. John Hyten during a Sept. 16 press conference at the annual Air Force Association Air and Space Conference. "The JICSpOC is to experiment on the new world we are walking into, not as a backup" to the JSpOC.

"Some of the things we will be working on will be the ferreting out of some strategic questions. One of the things as we have thought through this [is] we have a great deal of ongoing operational activity in the JSpOC," says Air Force Maj. Gen. Robert Rego, the mobilization assistant to the Stratcom commander. "There have been times when we really tied [the JSpOC's] hands. We don't give them the resources and the freedom to step away from the day-to-day mission to get after this type of experimentation." As a result, defense leaders worry that a slow reaction to a denial-of-service attack could allow it to spread unnecessarily if operators are not properly trained, rather than enabling them to isolate and nullify it quickly. Senior defense officials also need to think through the entire range of possible responses—military as well as economic or diplomatic pressures—in the event of an attack.

"That work has to go on in an experimental mode so we can really eke out and understand where it is we need to go, so that we can make better investments . . . and be able to deal with complexities we are seeing that our adversaries or potential adversaries are working on," said Adm. Cecil Haney, Strategic Command chief, during an Aug. 11 press conference at the Space and Missile Defense Symposium in Huntsville, Alabama. He described JSpOC's current approach as "clunky" compared to the art of the possible. "When you look at my JSpOC, right now it is an operational center that was built with a different concept in mind and at a time . . . when we felt we had more assurance of our capabilities in space and the preponderance of its responsibilities were to be able to account for things in space."

The JICSpOC has cost about $16 million to set up, and only one officer is permanently assigned to it. But roughly 30 people will work there temporarily to support operations over the next few months, Rego says, so it is not a major new program requiring substantial funding. Another objective is to use existing assets better and more efficiently, and to identify gaps that could be shored up with new technology.

Meanwhile, Stratcom and the NRO have also signed a memorandum of understanding codifying continued work to "strengthen U.S. space enterprise resilience" through the Joint Space Doctrine and Tactics Forum, according to Strategic Command officials. Though established in January, an Aug. 26 agreement outlines a way ahead for the forum. Its formation is a "watershed" event in the collective national security space environment, says Air Force Maj. Gen. Clinton Crosier, director of plans and policy for Strategic Command. Traditionally, defense and intelligence community officials have operated independently, and have coordinated only on an ad hoc basis regarding space operations.

Among the forum's near-term goals is drafting a new joint doctrine for space operations—taking into account shared work with the intelligence community and the new threat environment—by year-end, Crosier said in a Sept. 25 interview. The Pentagon, Strategic Command, Air Force Space Command and the NRO have also agreed to work together to share lessons learned about space activities from various disparate exercises.

These efforts are occurring in parallel to establishment of a new Commercial Integration Cell at the JSpOC. In a six-month trial that started in July, Air Force officials are allowing service and commercial operators to better share data about electromagnetic interference events. The goal is to craft procedures to improve collaboration among commercial and military satellite operators and determine if a more permanent arrangement would be useful.

These are some of the measures essential to what Work sees as a more favorable future environment for conducting intelligence operations in space. But his vision is larger. He hopes eventually to be able to use space-based assets not only to better understand what is happening on Earth and in space, but to provide tactical, timely intelligence on events around the globe. Space has historically provided key intelligence, but often not in tactically relevant time lines. The emergence of geospatial intelligence garnered from social media—including Facebook, Instagram and Twitter—provides an opportunity for the defense and intelligence communities to combine sources of intelligence to form more holistic views of events around the globe, especially those quickly unfolding.

"We find ourselves dependent now on space capabilities that are increasingly vulnerable to counterspace systems that others are developing"

"We want to know what the unusual looks like. All of a sudden, [if] a lot of cars show up in a parking lot of an adversary's missile plant, we want to know about it...quickly," Work says. "If Russian soldiers are snapping pictures of themselves in war zones and posting them on social media sites, we want to know exactly where those pictures were taken. If people start building islands or are starting to build structures on islands in the South China Sea, we want to know about it. And if [there is] a ship that we suspect might be carrying illicit materials, we want to know how deep it is sitting in the water so we can determine how much cargo is on board," he explains.

All of this could be possible with the support of space-based assets. But only if the government can maintain assured access to them, he warns.

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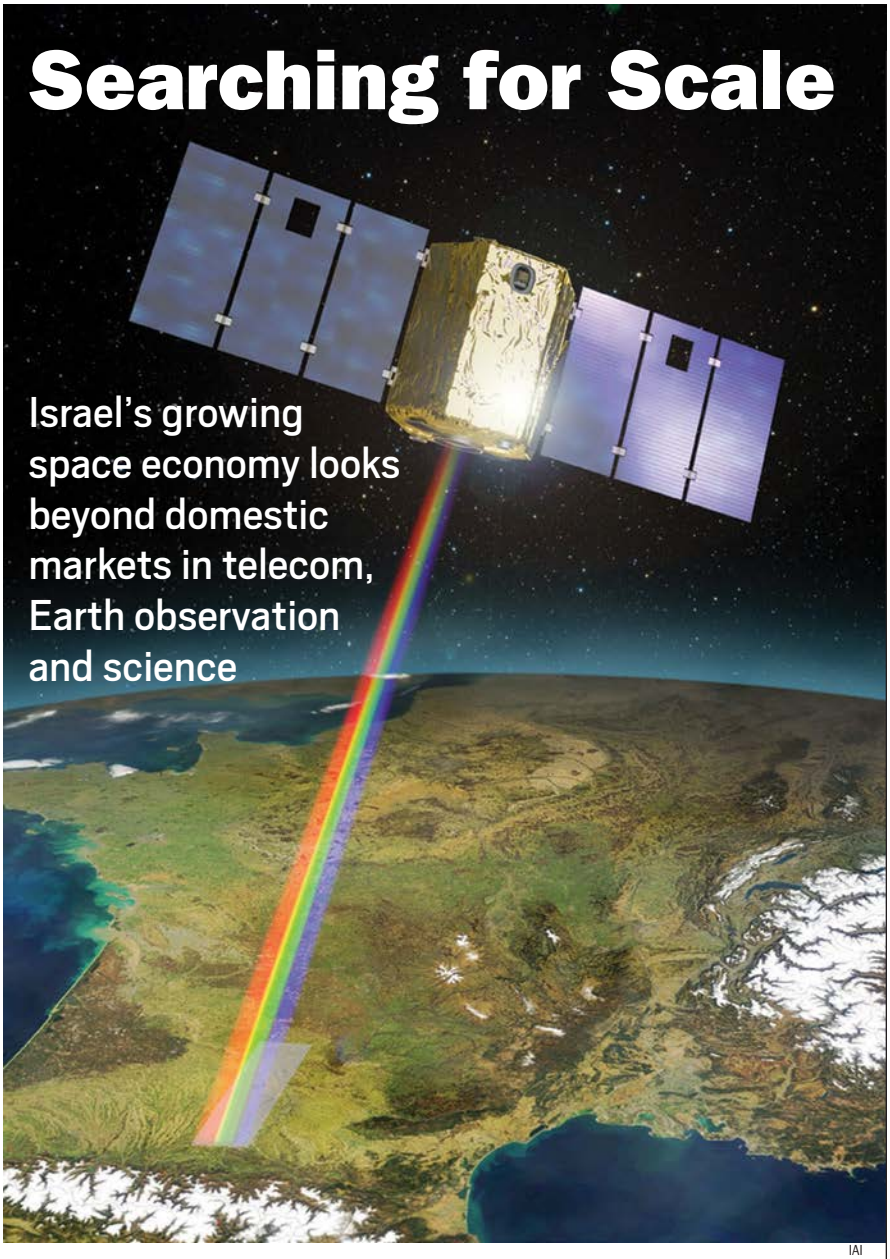


Israel's growing space economy looks beyond domestic markets in telecom, Earth observation and science

IAI

Amy Svitak Paris

A small country with a booming tech industry that draws liberally from military programs, Israel is struggling to end its dependence on domestic space markets. But as it learns to balance its defense needs against the increasing competitiveness of its aerospace companies, Tel Aviv is poised to emerge as a global player in three key sectors: telecommunications, exploration and commercial remote-sensing in space.

One of only nine countries capable of building, launching and operating its own spacecraft in orbit, Israel is also among a handful of nations served by both a domestic commercial fleet operator and commercial satellite imagery provider.

But with only a few satellites built and launched each year, Israeli companies are seeking to diversify their product offerings as they search for markets outside their borders.

"Israel's biggest problem in the area of space manufacturing and services is that the government needs to find a balance between the competitiveness of its industry and the price of maintaining the technical expertise needed for autonomous access to space," says Rachel Villain, an analyst with Paris-based Euroconsult.

With much of the nation's space manufacturing led by industrial prime contractor Israel Aerospace Industries (IAI), commercial programs have benefited largely from technologies developed for military telecommunications, remote sensing and launch, notably with the Shavit vehicle used to lift small Israeli milsatcom and spy satellites.

While this expertise has proved invaluable to evolving military capabilities into marketable commercial offerings, to date IAI has not sold a single commercial telecom satellite outside of Israel, where Spacecom is the nation's state-owned fleet operator and sole commercial customer.

Over the next several months, IAI and Spacecom will be busy preparing for the mid-2016 launch of the new IAI-built Amos-6 telecommunications satellite, which will be the largest the company has produced.

The Franco-Israeli Venus mission is an example of Tel Aviv's bilateral cooperation in space.

Construction and launch of the satellite—atop a SpaceX Falcon 9—is being financed in part with a $105-million loan from the U.S. Export-Import Bank. Weighing 5,300 kg (11,700 lb.) at launch, the high-throughput satellite will carry 45 transponders in K_a-, K_u- and S-band frequencies and feature an advanced hybrid propulsion system designed to extend its service life in orbit.

"It's a big jump in power from what they were doing before, as it will have a mini-high-throughput payload provided by MDA of Canada," Villain says. "It's completely new in terms of the power range, but they still have the problem of having to sell into a domestic market which is quite small, and relies heavily on military demand."

However, IAI may continue to struggle against established players in the telecom market for some years to come, she says, owing in part to its low annual production rate and limited experience in the commercial market.

"Because their product is a new one, it has to be flown before they can really enter the game and demonstrate the competitive advantage of their capabilities," she says, adding IAI may find a more marketable offering in the form of small telecom satellites, an area where IAI President and CEO Joseph Weiss sees increasing demand.

Weiss says IAI is working on a small all-electric comsat that would weigh up to 2,000 kg and be capable of carrying a payload equipped with 20 transpon-

ders. "We believe there is a niche market of operators that require a small satellite, whether due to slot limitations or to their business case, yet need to keep the cost reasonably competitive with larger satellites," Weiss says.

IAI is also working to improve its digital processing capabilities and provide more onboard flexibility while potentially enhancing a satellite's usefulness in orbit over its lifetime, he says.

In the meantime, Spacecom, Israel's publicly traded fleet operator, is facing its own challenge in seeking scale economies. More than a year ago the company was being eyed for purchase by a handful of operators, including Hispasat of Spain. A sale has yet to materialize, and Spacecom—with limited options for growth—is pushing to expand coverage into new areas, notably central Asia and Africa, in an effort to grow its reach beyond Israel and surrounding territories.

Most recently, Facebook and Paris-based satellite fleet operator Eutelsat announced they would pay nearly $100 million to lease all of Amos 6's K_a-band spot-beam capacity over Africa for five years. Eutelsat and Spacecom also have an agreement under which they share capacity via the Eutelsat 16A and Spacecom's Amos-5 satellites for television customers in Central and West Africa, as well as Madagascar.

Back on Earth, Israeli ground-terminal builder Gilat has had more success in export markets, notably South America and the U.S. A major competitor to Hughes, ViaSat, iDirect and Belgium-based Newtec, Gilat is focused on maintaining enough business to keep scale economies high and prices low. One current challenge is the impact of budget sequestration in the U.S., where sales to Pentagon customers are down. Gilat is concentrating on holding fast to its existing U.S. government business while waiting for a turnaround.

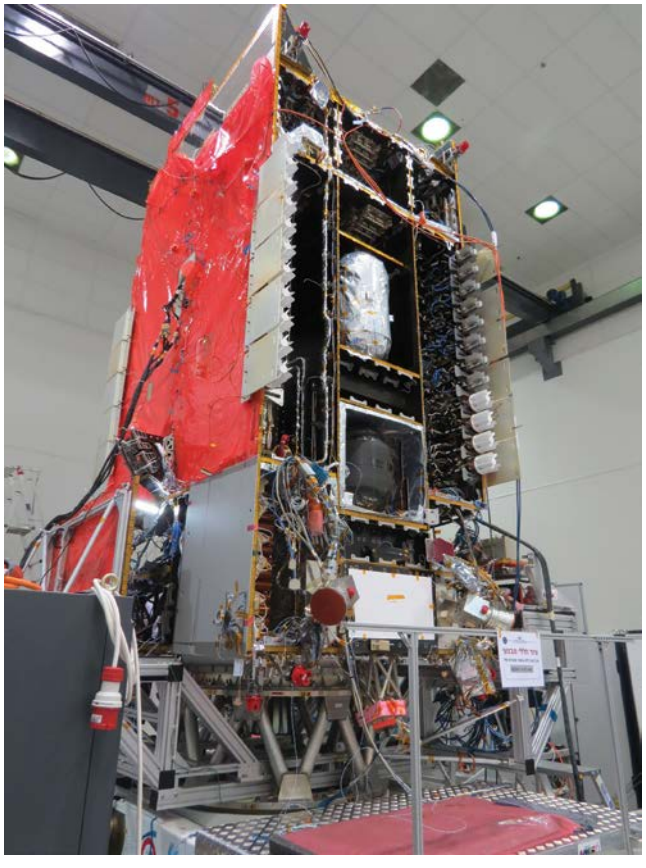
Earth observation is another area where Israel has begun to solve the problem of scale by linking its satellites to the size of its indigenous launch capability. Forced to lift military reconnaissance spacecraft on the small Shavit launcher, IAI and its supply chain have gained considerable expertise in developing small but highly capable optical and radar observation satellites.

While IAI has not yet won an export order in the Earth observation market, its sub-meter-resolution Optsat 3000 satellite has been sold to Italy as part of an offset agreement that includes Italian delivery of jet trainers, a deal that will give Europe a better sense of what Israeli Earth-monitoring satellites can do.

IAI is becoming increasingly active in seeking export customers for its remote-sensing spacecraft, notably by joining competitive bids in several nations, both on its own and through its imaging-service subsidiary, Imagesat, a company that competes with DigitalGlobe in the U.S. and Airbus Defense and Space in Europe.

IAI is now working with Elbit Systems and other subvendors to develop the EROS C optical imaging satellite for launch in 2019. A follow-on to the EROS B spacecraft currently in orbit, it will have resolution better than 50 cm (20 in.), suggesting it could be the first competitor to DigitalGlobe in the 30-cm resolution class of commercial Earth-observation imagery (see page 62).

The Israeli Space Agency (ISA) is also pushing beyond the nation's borders, primarily to play a role as a contributor to larger scientific campaigns. With an annual budget of around $50 million, the agency is supporting several cooperative efforts, including the Venus Earth-observation satellite being developed jointly with French space agency CNES.



IAI

Slated to orbit on a Falcon 9, Israel's Amos-6 comsat is running a year behind schedule due to launch delays.

ISA Director Menachem Kidron says Venus is in the final stages of integration at IAI. He says the mission will feature an electric-propulsion system developed at Rafael and a multispectral camera developed at Elbit Systems. Designed to photograph vast areas around the globe, Venus will provide dozens of images daily over a swath of about 700 sq. km (270 sq. mi.) to identify changes in soil and vegetation. It is slated to launch on a European Vega light launcher in late 2016 or early 2017.

ISA is also working on contributions to Europe's Jupiter Icy Moons Explorer mission to the Jovian System, including development of an Ultra Stable Quartz Oscillator instrument. Closer to home, the agency is working with the Israel Institute of Technology to develop the Samson mission, a cluster of three nanosatellites that will fly in tight formation at an altitude of 600 km, communicating with each other and the ground for more than a year.

"This is something which has not been attempted before," Kidron says. "This is going to be the beginning of constellations that fly together anyplace in space, with the idea that each one can be a part of a larger instrument, like an antenna or a camera." Kidron says the Samson mission may launch with Venus as a secondary payload on Vega in 2017.

Diversified Assets

High-resolution spy sats are just one part of Israel's commercial imagery offering

Amy Svitak Paris

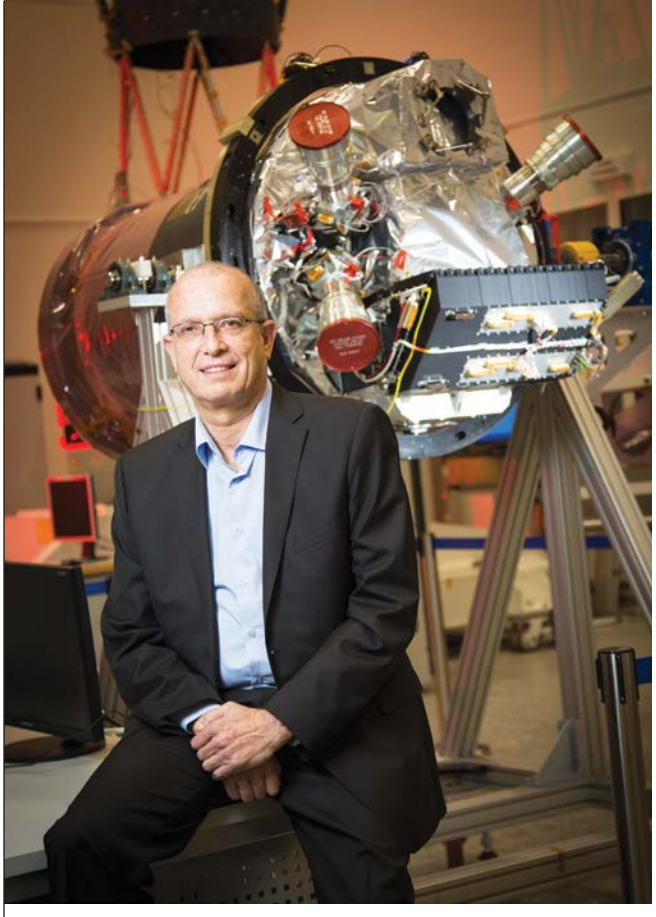
There are few nations with more interest in finding out what their neighbors are doing than Israel, which in part explains why its Earth-observation satellites are considered among the best in the world.

The Israeli government and its industry partners are now trying to leverage their military reconnaissance-satellite expertise—both radar and optical—into a commercial business that could put Tel Aviv on par with competitors in the U.S. and Europe.

To this end, satellite manufacturer Israel Aerospace Industries (IAI) and its ImageSat International subsidiary are plotting a new strategy to win export business, one that would capitalize on the aerospace and defense expertise of IAI by offering data products collected from UAVs and ground-based sensors, in addition to satellites.

"For us, the future is multisensor, multispectrum, and bundling this together as a service for a changing customer base—both emerging and traditional—to cater to all of them," says ImageSat International CEO Noam Segal.

Upon his arrival at ImageSat, Segal created a new UAV division within the company, and he says he plans to make the most of IAI's aviation and defense know-how to augment imaging services provided by ImageSat's EROS B satellite, as well as its planned successor, EROS C.



ALL PHOTOS IAI

IAI President and CEO Joseph Weiss says the company's proven capability in optical- and radar-imaging satellites should lead to success in export markets.

Israel's TecSAR reconnaissance satellite packs a powerful, high-resolution radar instrument into a compact, lightweight platform that weighs less than 300 kg.

"I hope soon we will have our own UAV platform, something we will have taken from the portfolio of IAI," Segal says. "Those platforms are really complementary in some places, specifically in urban areas, where satellites are not always the best sensors."

But for now, IAI is continuing work on the next-generation EROS C. Based on its new Optsat 3000 line of powerful, lightweight remote-sensing spacecraft, EROS C will offer sub-50-cm-resolution (20-in.) image products that could rival those offered by DigitalGlobe in the U.S. and Airbus Defense and Space in Europe.

Slated to launch in 2019, the EROS C mission has been postponed to allow time to make improvements to the satellite's Jupiter advanced optical-imaging detector, which is being developed at Elbit Systems' Electro-Optics (El-Op) division.

In recent months, the U.S. has lowered restrictions on the sale of commercial imagery at resolutions below 50 cm, boosting the ability of some service providers to market very-high-resolution data products. ImageSat, too, stands to benefit from the relaxation on commercial imaging resolution requirements, says IAI President and CEO Joseph Weiss.

"We have also had our restrictions lowered lately, so we do indeed see the boost coming," Weiss says. "It will enable us to fully use the Optsat 3000 capabilities and keep us moving away from the crowded, lower-resolution part of the market."

In addition to EROS C, Weiss says IAI is building several spacecraft based on the new Optsat 3000 platform, including

one for the Italian government as part of a government-to-government offset exchange between Tel Aviv and Rome.

In the meantime, he says IAI's Ofeq second-generation military reconnaissance satellites are performing well in orbit, including the most recent, Ofeq-10, which was launched in April 2014 on an Israeli Shavit launcher.

"This is still on the cutting edge of smallsat constellations, even though they were conceived two decades before the term became trendy," Weiss says.

With several Ofeq satellites in orbit, all weighing less than 300 kg (660 lb.), the second-generation system is providing 70-cm native resolution with what Weiss describes as exceptional collection capacity.

"Collection capacity is often overlooked and where shortcuts are usually made," he says. "Our users don't go for that approach. They don't just need good intel, they need lots of it, so we combine very high agility, multiple imaging modes, high onboard storage and very-high-capacity downlinks, combined with sophisticated collection planning, to enable just that—lots and lots of intel, every pass."

For subsequent generations of military reconnaissance satellites, IAI is working on all aspects of system design, both in-house and with suppliers.

Making the best of poor geographical location, the Shavit launcher lets Israel maintain autonomy in lofting military satellites.

"It's not a goal that can be achieved effectively [by] piecing together whatever you find off the shelf but rather requires an end-to-end view of tradeoffs and priorities," he says.

IAI is also focused on improving its line of TecSAR radar satellites. The company is building additional spacecraft, and Weiss says IAI is seeing a lot of interest from potential customers.

"TecSAR offers a unique capability to collect tactical intel, combining very high resolution with extreme agility and flexibility, and this is exactly what potential users are looking for," Weiss says. The platform is based on the same architecture as the company's latest-generation optical-imaging satellites, he notes, making TecSAR tailored for collecting a large number of very-high-resolution images. "We are constantly upgrading these as well, and the latest generation has received a larger antenna and improved resolution," he says.

Crossroads in Jerusalem

NASA shoots for Mars, others prefer the Moon

Frank Morring, Jr. Washington and Amy Svitak Paris

Scientists, engineers and human spaceflight visionaries from around Planet Earth will gather in Jerusalem Oct. 12 to ponder where to go in the Solar System after the International Space Station (ISS), how to get there and who will make the trip.

No matter what is decided—and it is unlikely anything definite will be—the robots have already been there. The 66th International Astronautical Congress (IAC) also will feature updates on visits to Pluto, Ceres and the Comet 67P/Churyumov-Gerasimenko, as well as briefings on upcoming missions to Jupiter, Europa, Mars and, perhaps, a tiny in-situ Kuiper Belt Object designated 2014 MU69 that is in the crosshairs of the New Horizons probe.

ESA/FOSTER + PARTNERS

NASA wants to send humans to Mars, but many of its partners believe returning to the Moon is a better idea. The European Space Agency developed this concept for a Moon base, 3-D-printed with lunar regolith as feedstock.

Israel is playing host to the annual event this year, using the occasion to showcase a civilian space industry that can play an important and growing role in the nation's export-driven economy. Israel Aerospace Industries Ltd. is opening its space center to IAC visitors with the full support of the ministry of science, technology and space and the Israel Space Agency.

"While our space program was originally built for military purposes, we are proud of the efforts that we have made over the past five years to adapt it into a civilian program that is furthering advancements in communications, environmentalism, science and technology on a daily basis," says Isaac Ben-Israel, chairman of the Israel Space Agency.

Although Israel produces some world-class spaceflight hardware, its west-facing coastline blocks it from efficient orbital launches to the east. NASA plans to sign a framework agreement in Jerusalem that will allow it to collaborate with the tiny agency on a variety of space projects, likely by helping put Israeli spacecraft into orbit.

The U.S. agency has the largest civil-space budget in the world, but its ambitious plans far outstrip the $19 billion it has managed to extract from the tight-fisted U.S. Congress for this year. International cooperation is crucial to all of NASA's goals, and it uses the IAC to promote it.

"I sent a personal letter out to all of the heads of agency and provided them with what we use right now to guide us," says NASA Administrator Charles Bolden of his plans for the upcoming Jerusalem session. "There's a matrix on technological challenges, or risks, and there's a matrix on human-research risks that we believe we have to buy down in order to feel comfortable putting humans on Mars. I sent them a letter saying, 'If you have a similar set of matrices, would you share them with us, and if you don't, would you take these and give them critical review, and then give us your candid, critical feedback on things that you think are already done that we don't show? Tell us if you think there are some challenges, some risks, that we haven't identified, or tell us if you think you've done something that has retired some of these risks.' I am hoping that we will spend a significant amount of time in our heads-of-agency meetings discussing that, in an effort to try to get all of us on the same sheet of music and focused on getting humans to Mars."

Getting everyone on that sheet of music may be an uphill slog for Bolden and his IAC crew. While it now appears likely that all ISS partners will go along with NASA's plan to continue funding the station until at least 2024, Mars does not appear to be the destination of choice for many of them.

Johann-Dietrich "Jan" Woerner, new director general of the European Space Agency (ESA), believes it makes more sense to return to the Moon first. He has called for a "Moon Village" on the lunar far side, where radio astronomers would be shielded from the noise broadcast from Earth and engineers could perfect the techniques needed to live and work in space.

Woerner, a civil engineer who first raised the idea when he was head of the German aerospace center (DLR), does not expect ESA to move quickly in that direction. Instead, he heads to Jerusalem with some new ideas for human operations in low Earth orbit after the ISS (see page 65).

NASA recognizes that its international partners have not embraced its long-term plan for a journey to Mars, which deliberately bypasses the lunar surface in favor of learning how to operate en route to Mars in the "proving ground" of cislunar space. The U.S. civil-exploration plan is deliberately vague on out-year details, to accommodate new technologies and funding developments. Its designers say there would be plenty of value in cooperative operations on the surface of the Moon that NASA could support from lunar orbit (see page 66).

One question frequently asked before each IAC is who will represent China. China's human-spaceflight organization is controlled by the military, while robotic space science is handled by the civilian China National Space Administration (CNSA). This year CNSA Administrator Xu Dazhe is scheduled to join Bolden, Woerner and Ben-Israel at the IAC's heads-of-agency plenary, along with Igor Komarov of Russian space agency Roscosmos, Naoki Okumura, president of the Japan Aerospace Exploration Agency, and others.

"Space has long proved to be a bridge that overcomes political problems we face here on Earth," says Woerner, who unlike Bolden and other NASA officials is not prohibited by law from bilateral cooperation with China."

SIERRA NEVADA CORP.

Germany's DLR and Sierra Nevada Corp. could use the latter's Dream Chaser vehicle to conduct microgravity experiments and orbital-debris mitigation in low Earth orbit.

Future Tense

New ESA chief urges continued ISS support, along with 'Moon Village'

Amy Svitak Paris

In late 2016, when European Space Agency (ESA) ministers meet to hash out a new round of multiyear funding, Johann-Dietrich Woerner hopes the agency's 22 member states will approve Europe's continued support for the International Space Station (ISS) beyond its current commitment to 2020.

But despite the likelihood of that—and that the ISS could remain operational for a decade or more—the incoming ESA chief says it is not too soon to start thinking about what comes afterward, especially given the number of years it takes to write an initial proposal, identify a large international partner, secure backing from multiple European states, distribute workshare across industry, and execute a mission that captures the hearts and minds of the tax-paying public.

"ISS will come to its end in something like 10 or so years," says Woerner, the former head of German aerospace center DLR, who took the helm of ESA July 1. "From my perspective, it is important to have the time to consider what should be done after the ISS."

Given the success of the five-nation ISS partnership, Woerner is hopeful any successor to the outpost would be founded on international cooperation. Privately, he has assembled a list of requirements for a follow-on development, including aspects of the microgravity science conducted on ISS, as well as the capacity to serve as a stepping-stone to more advanced space exploration. Based on this list, the ESA director general is proposing two multinational mission concepts, both of which he will discuss in more detail at the 66th International Astronautical Congress (IAC) in Jerusalem Oct. 12-16.

The first mission, a free-flying science lab, would continue ISS microgravity research in low Earth orbit (LEO) while advancing techniques and technologies for orbital-debris mitigation. The second, a so-called "Moon Village" on the far side of the lunar surface, offers the potential to further scientific endeavors in a low-gravity environment, using either humans, robots, or both. It also affords opportunities to set up a large radio telescope for astronomy research and to conduct in-situ studies on possible lunar sources of fuel and building materials that could support deep-space campaigns.

"The Moon might be interesting to international partners because it is relatively easy to reach from different spacefaring countries, so you don't have to cover all the special problems you have to tackle when you go to Mars," he says, adding that media coverage of the concept—after it was unveiled at the National Space Symposium in April—took the human component too far.

"People started to think about small private houses, a church, a city hall, but the word 'village' covers the different actors who could use it at the same time," he says. "It is not limited to humans, because it could also be a robotic village."

While some might see Woerner's interest in the Moon as a diversion from NASA's goal of sending humans to Mars, he says all of the world's space-faring nations are conducting lunar research on some level—both manned and robotic. His hope is that the Moon Village concept could pull these disparate efforts together under a common, collaborative initiative not unlike the ISS partnership.

"If we look to the U.S., China, Russia, they all have some projects referring to the Moon," he says, either as a direct destination in the case of Moscow and Beijing, or NASA's plan to conduct cislunar research ahead of a manned mission to the Martian system. "If you could combine these activities, we are at the point of the Moon Village."

International collaboration could also play a role in development of a free-flying microgravity research lab in LEO, a spacecraft that could likewise be equipped to address the growing problem of orbital debris. Woerner says the project could involve the cargo variant of Sierra Nevada's lifting-body Dream Chaser vehicle launched under the fairing of the next-generation Ariane 6, being developed at Airbus Safran Launchers.

Dream Chaser could capture defunct satellites or large pieces of debris using a robotic arm, such as the one in development for the German-led DEOS orbital servicing demonstration. The vehicle could also use lasers to shrink or redirect very small bits of space junk.

Woerner says the laboratory part of the concept is attractive to researchers seeking more timely turnaround than the ISS currently affords. "It could go up and down in short periods, in order to allow frequent and rapid access to microgravity experiments," he says. "With the station, it takes too long to send up the research and get back results."

Whether either of these concepts will gain traction at IAC—or among ESA nations at next year's ministerial meeting—remains to be seen. For now, despite Woerner's interest in a lunar campaign, ESA's sole space exploration program is the $1.35 billion ExoMars mission it is developing with Russia, a two-pronged campaign that will send a European trace-gas orbiter and rover to Mars over the next three years.

In the meantime, ESA has yet to decide whether to continue supporting the NASA-led ISS to 2024, a decision that will be weighed next year against other agency priorities: In addition to ExoMars and other space-science missions, ESA funds a gamut of programs, everything from Earth observation and navigation satellites to telecommunications technologies and future launch vehicles—all within a $5 billion annual budget.

Still, Woerner is optimistic that the agency will approve the ISS extension, noting upcoming missions of European astronauts to the space station that could draw continued support among member states.

"I hope we will get confirmation for some additional years," he said, noting that ESA's current commitment to 2020 includes a roughly two-year ramp-down that would see the agency's activities reduced at the station after 2018. "It's an important issue in the next ministerial for Europe to decide whether to go on with human exploration on the ISS or not. It is a very simple question, but a difficult answer."

Red Planet Pitch

NASA managers face partners with different ideas at space congress

Frank Morring, Jr. Washington

U.S. spaceflight managers will move their area of operations from Capitol Hill to Jerusalem this week, using the 66th International Astronautical Congress (IAC) to pitch NASA's long-range plans for exploring Mars with humans and robots to the international partners they believe will be essential for the work. Not all of them agree with the target.

As the U.S. Congress wrangles over funding another year of spaceflight operations amid a plethora of competing demands on the Treasury and the distractions of the coming change in presidents, Administrator Charles Bolden and his lieutenants are scheduled to update their counterparts at the IAC on their evolving architecture for landing humans on the red planet someday. Many of NASA's partners, including Europe's new space chief, have other ideas.

NASA's agenda also unveils a new framework agreement that will allow the U.S. to begin cooperative space activities with Israel, the IAC host, and advances work on the maze of other international projects that typify much of the human space endeavor today. A joint synthetic-aperture radarsat with India is but one example (see illustration, page 63).

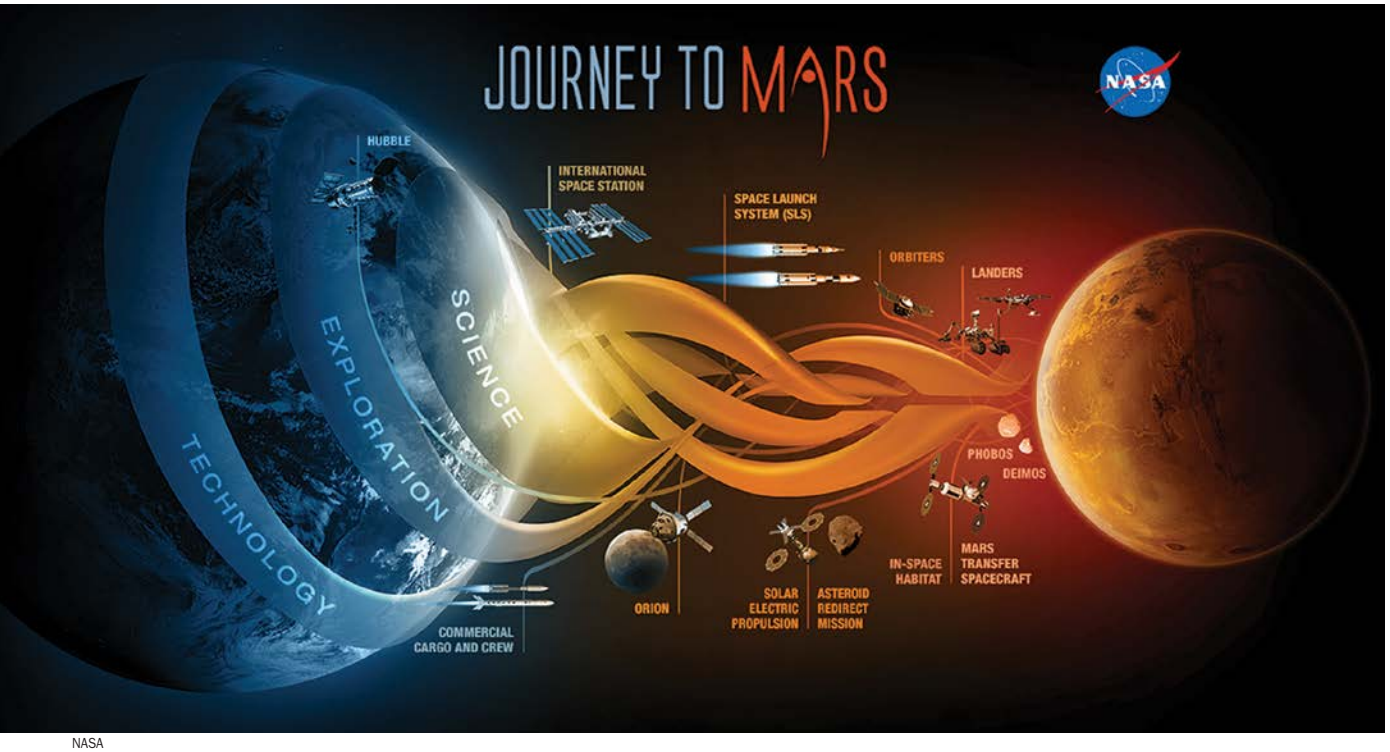
"We want to pick up the pace of international collaboration and cooperation in exploration, both robotic and human, so that we speak with the same voice when we talk about what our goals are, what our intermediate waypoints are, and how we treat the approximately 10 years, the decade of the '20s," says Bolden. "While the U.S. is focused on a lot of technology development needed to get humans to Mars, in the 2020s and cislunar orbit, we want our international partners to be as vibrant as we are there. We want their ideas about how we maximize our utilization, how they want us to help them accomplish objectives that they want."

The IAC kicks off with a public panel of agency chiefs, an annual event that enables them to pitch their programs and take a few questions. After that will come a series of bilateral sessions out of the public eye where a lot of the real space-agency business of the IAC takes place. Bolden is scheduled for seven or eight such sessions, plus multinational meetings. In addition to long-term human exploration, he says topics on his agenda will include international standards for space-based elements of air traffic control systems and looking for ways space agencies can work together for science, technology, engineering and math (STEM) education.

As NASA promotes its plans to explore Mars with humans, other agencies are looking to the surface of the Moon for their next steps in space. Johann-Dietrich "Jan" Woerner, the new director general of the European Space Agency (ESA), believes a human base on the far side of the Moon would be a more realistic exploration goal for now. He started promoting the idea while he was head of the German aerospace center (DLR) and has been testing member-state backing in his new role at ESA. Support there is far from solid, given the expense of such an undertaking, and Woerner is taking some less-ambitious ideas to Jerusalem as well (see page 61).

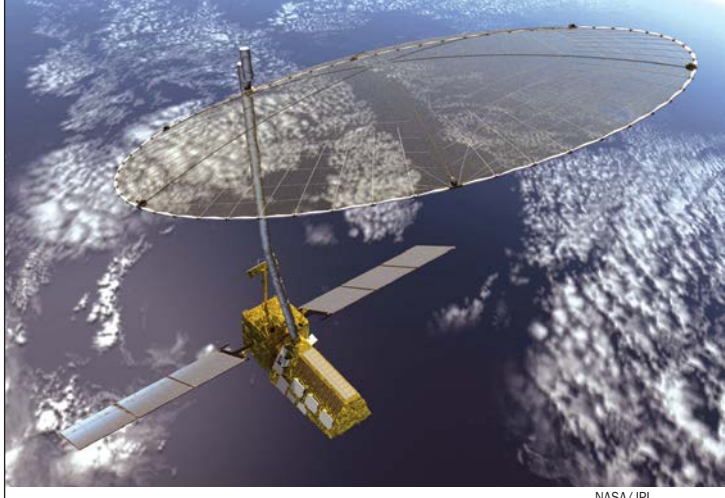
NASA officials expect the Moon-vs.-Mars issue to come up at the IAC, and they say they are ready to help their partners push lunar goals if they can. Bolden notes that the Global Exploration Roadmap hammered out among the world's space-faring nations declares that "the ultimate destination for humanity is Mars"—but it is not the only one.

The Moon's surface doesn't figure in NASA's human-exploration plans, but many of the U.S. space agency's international partners want to stop there first.



NASA

NASA and the Indian Space Research Organization will touch base at the IAC on their joint synthetic aperture radar spacecraft, Nisar.



NASA/JPL

"There are other points along the way where the individual partners may want to pursue their interests," Bolden says. "Jan's idea I think is great. I would love to have an opportunity to put an American astronaut on the surface of the Moon while we're doing research in cislunar space, because it will give us that many more data points about what happens to the human body in a less-than-1g environment, which is better preparation for Mars. [The] lunar surface for the U.S. is not essential, but the lunar surface for the U.S. would be a great plus."

Even before completion of the International Space Station (ISS) marked the end of the Cold War space race, the ISS partners—NASA, ESA, Russian space agency Roscosmos, the Japanese Aerospace Exploration Agency (JAXA) and the Canadian Space Agency—realized they had a model for future human space exploration as well. With its $19 billion budget, NASA has the largest civil space program, and it intends to use that fiscal clout to take a leadership role in a future space exploration program. The agency's new report for Congress, *NASA's Journey to Mars; Pioneering Next Steps in Space Exploration*, calls for an approach that "builds on our existing international partnerships while embracing new ones."

The ISS was cobbled together with components—launch vehicles, pressurized modules, power, data and other systems, and robotic tools—provided by the station partners. NASA envisions a similar approach as it moves into the "proving ground" in lunar orbit, on to the vicinity of Mars and eventually down to the planet's surface. If some partners want to stop at the Moon on the way, NASA has specific ideas for helping them, chief among them use of the heavy-lift Space Launch System (SLS) and Orion crew capsule now in development to support human—and robotic precursor—operations on the lunar surface.

"We'll be there with Orion around the Moon," says William Gerstenmaier, NASA's associate administrator for human exploration and operations. "We have roughly 21 days of capability—that's roughly seven days in lunar orbit with Orion. If we put some kind of habitation capability around the Moon at the same time, we can get a couple of weeks of lunar-orbit stuff."

From a habitation-augmented Orion in the distant retrograde orbit that NASA favors for early cislunar operations, astronauts could teleoperate rovers on the Moon's surface to learn to prospect for water ice to provide oxygen and hydrogen for life support and propellants needed on "Earth-independent" missions to Mars. They can also check out the technology NASA's partners would need to set up a human Moon base, starting with a lander.

"If you want to do some precursor rovers, which we would like to do to see if there's resources on the Moon that could be used for a Mars-class mission, those rovers could be compatible for what a pathfinder might be for ESA or for some other country to go take a look at in terms of the Moon," Gerstenmaier says. "If they have the funding to go build some kind of human-class lander, maybe instead of going from a spacecraft, you could go from some kind of habitat and Orion system that we have there doing our proving-ground objectives. So I would say our proving ground objectives in cislunar space are not incompatible with what could potentially come from ESA and the partners in terms of lunar-surface activities. They could actually complement each other if we move forward."

That is not to say that dramatic new partnership agreements are likely to come out of Jerusalem. In September, both NASA and ESA registered delays in key exploration programs, demonstrating again that progress beyond low Earth orbit comes slowly. Top NASA managers conceded they don't have the required level of confidence to launch humans on a lunar flyaround in an Orion capsule before 2023—two years later than initially targeted. And ESA delayed the planned launch of its ExoMars-1 Trace Gas Orbiter mission to March from January to remove a pair of faulty pressure sensors that could cause problems with the mission's Schiaparelli entry, descent and landing module prototype (*AW&ST* Sept. 28-Oct. 11, p. 67).

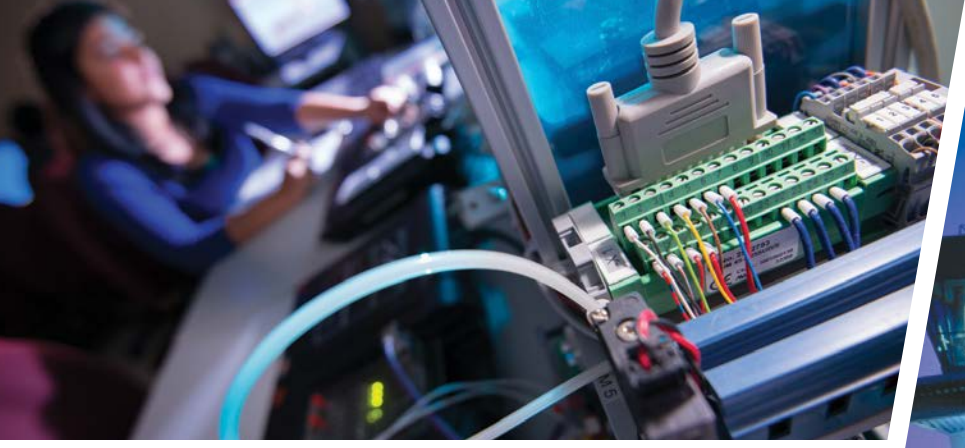
Despite the setback in Orion's first human flight, Bolden and his colleagues believe they will go into their IAC meetings with enough momentum on funded human exploration projects to overcome any partner concerns that the 2016 U.S. presidential election will change everything. Orion survived President Barack Obama's decision to cancel the Bush administration's Constellation program of exploration vehicles, and the SLS that will take Orion to space is scheduled to fly with an unmanned Orion in 2018. Even if a new U.S. administration shifts the focus away from Mars and back to the Moon, as some Republicans advocate, the SLS and Orion will be needed to get there, along with the life-science and technology work underway on the ISS.

"We can make those three pieces clear to the next administration, that these are priorities for us in human spaceflight," says Gerstenmaier. "We've got lots of knobs and options. . . . [We've built] a strategy that lets the next administration come in and have a very strong say in what we do in the next few years, but it doesn't impact the base that we're built on."

One of the attractions of the lunar far side that Woerner cites is the radio silence there, shielded as it is from Earth's high-power broadcasting. Astronomers see it as a perfect place to set up large radio telescopes. China reportedly is targeting its next robotic lunar-landing mission, Chang'e-4, on the far side, and has just signed a letter of intent to participate in the proposed Square Kilometer Array (SKA), which would be the largest radio telescope on Earth.

NASA's ability to cooperate with China is severely restricted by Congress on human-rights grounds, although there is some low-level collaboration in Earth science and lunar exploration. NASA provided some ground-truth data for Chang'e-3, and Bolden says the agency may help with Chang'e-4 as well.

"While I have no intention whatsoever of violating the law, what I'm trying to do as the NASA administrator is work to facilitate the future success of any agreed-upon collaboration between the U.S. and any partner, to include China," says Bolden.



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Mars Ascending

Packaging and propulsion are among key challenges facing designers for low-mass Mars liftoff

Designed to fit snugly within the 10-meter-dia. (33-ft.) Space Launch System fairing, the MAV and its cryogenic fuel will be cooled with large external radiator panels.

NASA CONCEPT/AW&ST ART DEPT.

Guy Norris Los Angeles

As Hollywood's vision of how astronauts might one day escape from Mars debuts in the new science fiction movie "The Martian," NASA is moving forward in the real world with studies of concepts for an ascent vehicle to lift humans from the surface of the red planet.

Even though human exploration missions are not likely until the 2030s, initial design studies already show that the Mars ascent vehicle (MAV) will be very different from the ascent stage of the Apollo Lunar Module, the only craft ever to carry humans off the surface of another planetary body. The MAV will have to be "significantly more massive," says NASA Marshall Space Flight Center's human architectures team lead, Tara Polsgrove.

In addition to dealing with more than double the gravity of the Moon plus the weight of up to four crewmembers—twice that carried by the Apollo lander—the MAV will require a much larger propulsion system to meet the higher delta V (velocity change) requirements of the Mars ascent trajectory. Time-to-docking is also longer for Mars, with an ascent time of 24-44 hr., compared to 2.1-3.7 hr. for Apollo.

The difference in mission requirements is clearly reflected in the total mass of the latest MAV concept, one of many options being considered as part of a potential transport architecture for Mars. In this latest study, aimed at minimizing the mass of such a vehicle, the MAV weighs in at 39,075 kg (86,000 lb.) compared with 4,795 kg for the Apollo ascent stage. Ascent delta V for the MAV would be 5,274 meters per sec. (17,000 fps) against just 1,900 meters per sec. for Apollo. The required propellant would be more than 29,650 kg compared to just 2,492 kg for the Lunar Module.

Polsgrove detailed the results of a study to refine mass estimates for a conceptual four-person MAV at the American Institute of Aeronautics and Astronautics Space 2015 conference in September. She said design of the vehicle has a "significant effect" on the entire Mars transportation architecture. "Changes in MAV estimates ripple back" and affect the entry and descent-stage design of the lander as well as the launch vehicle from Earth, she added. The study was initiated in late 2014, after earlier NASA work indicated a potential 3-ton (6,000-lb.) gap in performance between the 43 tons at Mars entry, thought to be needed for a minimum design lander, and the 40 tons estimated mass that a solar-electric-powered spacecraft could deliver to Mars orbit.

The MAV concept also follows baseline design principles outlined by a NASA Johnson Space Center team that recommended the vehicle be used for ascent only, rather than as a dual-use craft for descent and habitation. The MAV would therefore arrive on the planet as part of an integrated Mars Descent Module that would enter the atmosphere attached to a large inflatable decelerator or some other reentry vehicle. Other recommendations to minimize mass include limiting MAV use to 24 hr. or less, and using special suits for ascent, leaving bulky suits used for surface extravehicular activity (EVA) behind. In addition, it recommended that crews enter the MAV from a Mars rover or habitat via a detachable tunnel to save the structural mass involved in a hatch.

Under the concept study, the MAV is primarily viewed as a means of lifting crew and cargo off the Martian surface and docking with an orbiting Mars-Earth transport vehicle. How-

ever, Polsgrove says the design space remains open and "everything is still on the table." She adds that interest in exploring the Martian moons of Phobos and Deimos has also prompted interest in using part of the MAV as a crew taxi to transfer between the moons and the Earth return vehicle. Several design changes would be required for this variant, including added waste management for the crew, who would have to spend up to three days in the small cabin, as well as structural beefing-up to support launching from Earth with full liquid oxygen (LOX) propellant tanks, since in situ production would not be possible on this mission.

To save mass for the Mars lander version, however, the MAV will be predeployed without oxygen propellant years in advance of the crew's arrival. The vehicle would typically spend 2.5-3.5 years on Mars, of which at least one full year will be required for propellant generation while on the surface. A fission power source, delivered with the MAV or on an earlier mission, would provide power for oxygen production and prevent boil-off of the ascent propellants.

In the recent concept configuration unveiled by NASA, the MAV is a two-stage vehicle with three 100-kn-thrust (22,500-lb.-thrust) LOX/liquid methane engines on the first stage and a single engine of the same thrust on the second stage. Engines and nested fuel and oxidizer tanks are clustered around the centrally located crew cabin, and are packaged to enable the entire vehicle to be housed within the 10-meter-dia. fairing of the Space Launch System vehicle. "This is one possible arrangement. It gives a low center of gravity to the lander and helps control during descent and landing. It also gives the crew easier access. We don't want them to have to climb several stories to get in the vehicle," says Polsgrove.

NASA's study envisages a launch from the 30-deg. north latitude, ending in the initial low Mars orbit of 100 km X 250 km (62 mi. X 155 mi.). The three first-stage engines and associated tanks are designed to drop from the MAV after the first-stage burn. Liftoff acceleration is very gentle and expected to be 0.78 Earth Gs, hitting a maximum of only 1.52g when staging occurs at almost 226 sec. into the flight. The second stage, containing the 2.7-meter-dia. crew cabin, continues under power from a single engine fueled from two sets of nested propellant tanks. Maximum acceleration during this 192.6-sec. burn is expected to be 1.10g. Although shorter flights to rendezvous with the Earth-bound transport are feasible, NASA planners have calculated propellant loads that assume a 24-hr. flight and crew consumables for a 44-hr. flight. The combination allows a one-day ascent if the conditions are right, with a built-in margin for a longer flight if needed, says the report.

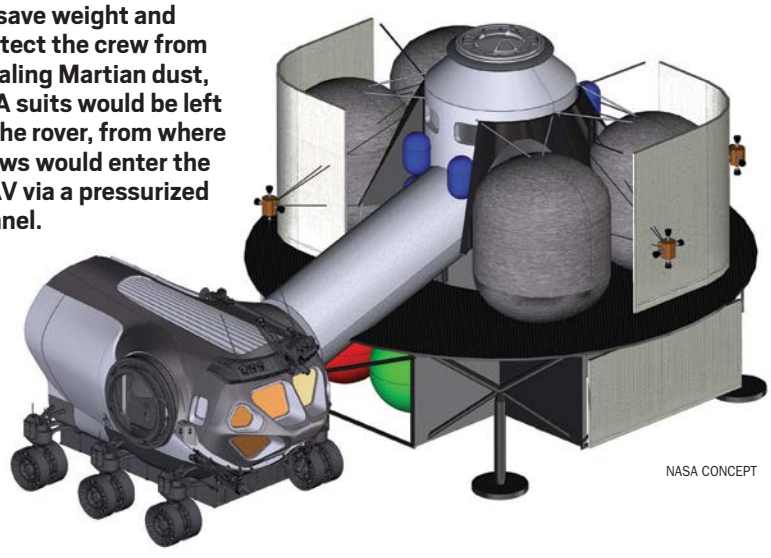
In addition to factoring in the different gravity on Mars—63% lower than on Earth but more than double that of the Moon—the study also had to account for aerodynamics. Although atmospheric pressure on the surface of Mars is only around 0.6% of Earth's sea-level pressure, Polsgrove says it is thick enough to cause drag, particularly at lower levels.

Power for the vehicle is provided by three solid oxide fuel cells, which draw oxygen and methane from the second-stage propellant tanks. The study assumes 60% fuel-cell efficiency, and is based on technology now being developed at NASA's Glenn Research Center. Heat loads, heat rejection and propellant conditioning will be provided by a thermal control subsystem, which must be able to operate under a vast range of temperature extremes such as the cold-to-warm diurnal conditions on Mars to the deep cold of the transits to orbit.

To protect the crew from heat loads, the cabin will be wrapped with layered composite insulation with a black Kapton outer layer, while internal temperature will be maintained by shell heaters. The MAV thermal control will also be fully integrated with the lander, and the two will be designed to operate as one subsystem for the outbound flight as well as during the stay on the surface. Polsgrove says this approach allows the MAV to carry a minimum amount of thermal control hardware.

The long dormancy period of the MAV, plus the short duration of its actual mission, required that special consideration be given to the life-support system, based to a large extent on the design created for Altair (the lunar lander from NASA's 2010 canceled Project Constellation). Changes include an enhanced water purification capability and additional nitrogen and oxygen supplies for the cabin atmosphere to allow for leakage during the MAV's long stay. The unusually short duration of the MAV mission is also reflected in the relatively Spartan provisions for the crew. Unlike longer-stay vehicles, the MAV will not have a food warmer, an exercise machine or even a lavatory. The MAV will be equipped only with food, hygiene supplies such as wet wipes, absorbent garments and safety gear such as radiation dosimeters and a tool kit for contingencies such as a jammed hatch mechanism.

The MAV study is also helping to spot and prioritize technologies and capabilities prior to vehicle development. These cover nine key areas: avionics, communications, life support, propulsion, EVA, biomedical countermeasures, in situ resource utilization, power and thermal control.



To save weight and protect the crew from inhaling Martian dust, EVA suits would be left in the rover, from where crews would enter the MAV via a pressurized tunnel.

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Aviation Week & Space Technology
October 12-25, 2015 VOL. 177, NO. 20
(ISSN 0005-2175)
1166 Avenue of Americas, New York, N.Y. 10036

Member of Audit Bureau of Circulations and Magazine Publishers of America. Published biweekly by Penton Media Inc., 9800 Metcalf Ave, Overland Park, KS 66212-2216. Periodicals postage paid at Kansas City, MO and additional mailing offices. Canada Post International Publications Mail Product Sales Agreement No. 40026880. Registered for GST as Penton Media, GST # R126431964. Title reg.® in U.S. Patent Office. **Postmaster:** Send address changes to Aviation Week & Space Technology, Attention: Subscription Services, P.O. Box 1173 Skokie, IL 60076.

Future Events

Nov. 3-5—MRO Asia-Pacific. Singapore.
Nov. 3-5—AerospaceDefenseChain. Scottsdale, Arizona.
Jan. 21-22, 2016—MRO Latin America. Lima, Peru.
Feb. 3-4, 2016—MRO Middle East. Dubai.
Feb. 15, 2016—ATW's Airline Industry Achievement Awards. Singapore.
March 3, 2016—Aviation Week Laureate Awards. Washington.
March 7, 2016—SpeedNews 6th Annual Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.
March 7-9, 2016—SpeedNews 30th Annual Commercial Aviation Industry Suppliers Conference. Beverly Hills, California.
April 5-7, 2016—MRO Americas. Dallas, Texas.

Aerospace Calendar

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Oct. 19-22—Airports Council International-North America's 2015 Public Safety & Security Fall Conference. Arlington, Virginia. See aci-na.org/event/5215
Oct. 20-22—JEC Asia. Suntec International Convention & Exhibition Center. Singapore. See jeccomposites.com/events/jec-asia-2015
Oct. 20-23—Aerodays 2015 Conference. QE11 Centre, London. See aerodays2015.com
Oct. 22—Aerospace Components Manufacturers 2015 Trade Show. Hartford/Windsor Airport Marriot. Windsor, Connecticut. See aerospacecomponents.org/page4230.html
Oct. 26-28—Cargo Facts Symposium. Mandarin Hotel. Miami. See cargofactssymposium.com/
Oct. 26-28—Fatigue Concepts: Corrosion Control. Hilton, Salt Lake City. Call +1 (916) 390-5000 or see fatcon.com/s
Oct. 27-29—American Astronautcial Society Wernher von Braun Memorial Symposium. University of Alabama-Huntsville. Huntsville, Alabama. See astonautical.org
Oct. 27-29—AHS International Technical Meeting on Rotorcraft Propulsion. Fort Magruder Hotel and Conference Center. Williamsburg, Virginia. See vtol.org/events/ahs-international-technical-meeting-on-propulsion
Oct. 28-29—CIMData's Product Lifecycle Management Road Map for the Aerospace & Defense Industry. The Westfields Marriott. Chantilly, Virginia. See cimdata.com/en/education/plm-conferences/2015-plmrm-ad-cic
Nov. 1-6—Airshow China. Zhuhai, Guangdong, China. See airshow.com.cn
Nov. 8-12—Dubai Airshow. Dubai World Central. Dubai. See dubaiairshow.aero
Nov. 10-12—International Aviation Women's Associations 27th Annual Conference. Fairmont the Palm. Dubai. See iawa.org
Nov. 17-18—APEX Technology Conference. Hyatt Regency Newport Beach. Newport Beach, California. See connect.apex.aero/events/event_details.asp?id=505136

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**International edition

Who's Missing the Mark on Emissions?

Four industry groups wrote this collective statement on fuel efficiency and carbon-dioxide emissions. The International Coordinating Council of Aerospace Industries Associations (ICCAIA) is the global organization of aerospace industry associations. The International Air Transport Association's (IATA) 250 member airlines account for 83% of the world's air traffic. The International Business Aviation Council (IBAC) represents and promotes business aviation industry. And the General Aviation Manufacturers Association (GAMA) is a group of 80 of the world's leading manufacturers of general aviation aircraft, engines, avionics, components and related services.

The world aviation sector is well on its way to meeting the planned fuel-efficiency targets set for 2020. Despite the Leading Edge column to the contrary (*AW&ST* Sept. 14-27, p. 19), ICCAIA, IATA, IBAC and GAMA agree that the International Civil Aviation Organization's (ICAO) fuel-efficiency goals are within reach and supported by the aviation industry's strong record to date and commitments going forward.

> "Despite having a strong fuel-efficiency and emissions-savings record, our industry was the first global transport sector to adopt concrete CO_2 emission-reduction goals."

While we recognize the acknowledgment in the column of the significant achievements in aircraft technology, we would like to clarify that the ICAO goals involve participation by the whole aviation sector using a broad array of measures, not just aircraft technology. The ICAO CO_2 emissions goal states: "States and relevant organizations will work through ICAO to achieve a global annual average fuel-efficiency improvement of 2% until 2020 and an aspirational global fuel-efficiency improvement rate of 2% per annum from 2021 to 2050, calculated on the basis of volume of fuel used per revenue tonne kilometer performed."

Despite already having a strong fuel-efficiency and emissions-savings record, our industry was the first global transport sector to adopt concrete CO_2 emission reduction goals. The industry is working to meet these through a basket of measures consisting of improved aircraft fuel efficiency—through the introduction of new aircraft models and propulsion systems and operational efficiencies; air traffic management system modernization and improvements; and greater use of sustainable aviation biofuels. Since making these commitments in 2009, the aviation industry has improved its fuel efficiency by an average of more than 2% per year up to 2014.

An International Council on Clean Transportation report—and the Leading Edge column based on it—creates an impression that the goals agreed by the ICAO Assembly are for new technology alone. This is a mischaracterization. They are actually for overall efficiency, taking into account the range of measures described above.

Today's commercial aircraft consume 70% less fuel per passenger mile than aircraft did 50 years ago. Even as it has grown, the aviation industry continues to invest billions of dollars every year in the development and deployment of new technologies to further fuel efficiency gains and lower emissions. New aircraft bring this technology to the world with greater fuel efficiency; for example, the Boeing 787 is 20% more fuel efficient than its predecessor, and the Airbus A320neo improvements result in 20% fuel savings per seat compared with the A320 current engine option. These aircraft are not just improving their fuel efficiency but are designed to address other key, and frequently interdependent, environmental issues such as local air quality and noise, alongside the paramount safety requirement. And airlines are keenly focused on operating their aircraft as fuel efficiently as possible.

The global CO_2 standard and market-based measure both under development at ICAO represent major steps for the aviation industry toward carbon-neutral growth. Governments, industry and civil society are all working together under this organization to achieve global agreement. This is founded upon four key ICAO principles: to establish global standards that are environmentally beneficial, technically feasible, economically viable and take account of interdependencies with other environmental standards. We are confident that together we can meet these principles and reach the goals on top of an already impressive fuel-efficiency and CO_2-savings record.

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