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24 *U.S. and European airlines have put the issue of alleged subsidies for the Big Three Gulf carriers including Dubai-based Emirates, with its growing fleet of Airbus A380s, high on the political agenda.*

COMMERCIAL AVIATION

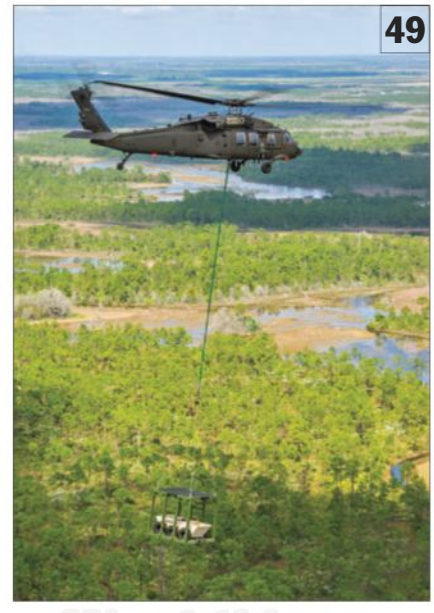
DEFENSE

TECHNOLOGY

ON THE COVERS

This week, Aviation Week publishes two print editions. On the cover of both, the U.S. Navy's Northrop Grumman X-47B unmanned combat aircraft demonstrator receives fuel from an Omega Boeing K-707 tanker, marking the first time an unmanned aircraft has been autonomously refueled in flight (page 64). U.S. Navy photo. Elsewhere in both editions are reports on Sikorsky's work on autonomous flight (page 49), synthetic vision guidance (page 53), Japan's radical idea for replacing fighters (page 32) and Dream Chaser (page 61). Our Defense Technology International edition includes an additional section.

Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*



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. Fax to (202) 383-2346 or send via e-mail 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.

PAIRING GONE WRONG?

As a retired Marine with a decent background with the "gator navy" (amphibious ships), I eagerly read about the steps being taken to operationally field test the F-35 with the Fleet Marine Force in "Back to Sea" (*AW&ST* April 27-May 10, p. 40). Even casual aviation watchers know this airframe is mired in controversy related to cost vs. efficacy.

I assumed the Defense Department would take a more hawkish view on wasteful spending given the bad press surrounding this airframe, so I was taken aback when I read the USS America (LHA-6) would have its flight deck and spaces directly underneath that deck undergo a costly modification to support this aircraft.

Why does a billion-dollar big-deck amphibious ship that was just launched with this aircraft as its backbone need to be modified?

This ship and aircraft were supposed to be as suitable a pairing as peanut butter and jelly—and now we are at $17 trillion and counting.

Phillip Corbett
CORVALLIS, MONTANA

DOLLAR DISCONNECT

"Back to Sea" discusses the sea trials for the U.S. Marine's F-35B, in preparation for initial operational capability as early as July. The Marine version is estimated at $251 million, while the Navy's version—F-35C—is slated at $337 million.

The versions seem similar in form and function, other than the basing requirements of which the F-35B would appear to have a more sophisticated development challenge as a short-takeoff-and-vertical-landing (Stovl) aircraft.

Are the U.S. Marines just better at math, or is this yet another case of incongruous defense spending?

Tom Carey
FREELAND, WASHINGTON

(The cost figures you cite include the price of development amortized across the projected buy, so are higher than the "flyaway" price for current lots that are closer to $100 million, not including the engine.

The price difference reflects the Marine Corps' benefiting from the physics of the buy. The USMC buy has been top priority for the Pentagon since the Stovl weight-reduction program in 2006-07, so more B versions are being purchased than Cs; the "per unit" cost is skewed until a higher quantity of Cs are purchased.—Ed.)

CAP ON THE CASE

"Danger Close" (*AW&ST* March 30-April 12, p. 54) raises interesting points about training. One is that another option to train joint terminal attack controllers (JTAC) is to use contract aircraft. But please note, the U.S. Air Force already uses contract aircraft to train JTACs at the National Training Centers at Fort Irwin, California, and Fort Polk, Louisiana.

The Civil Air Patrol (U.S. Air Force Auxiliary) has been performing this mission for the past five years. Under the supervision of the 549th and 548th Combat Training Sqdns. at Nellis AFB, Nevada, and Barksdale AFB, Louisiana, the CAP has flown in every Green Flag training exercise since 2010.

The unit emulates tactics, techniques and procedures (TTP) of an MQ-1 Predator or MQ-9 Reaper with a manned aircraft. Aircrews receive the latest TTP that is used in-theater to provide realistic training to most servicemen.

CAP Cessna C-182s and Turbo C-206s provide JTACs with training in all areas of close air support (CAS).

This all-volunteer force fills a critical gap in the support of JTAC training for the Air Force.

CAP Lt. Col. Joseph M. Vallone
NORTH LAS VEGAS, NEVADA

PROVOCATIVE, BUT UNBALANCED

Antoine Gelain's call for broader adoption of a software focus in both technology and business practices (*AW&ST* April 13-26, p. 12), while thought-provoking, is a bit overzealous. Comparing the market caps of Boeing and Airbus with Apple and Google does not show us we are falling behind. Instead it illustrates the gulf between private-sector and consumer-driven growth potential, and the much flatter curve offered by government and airline customers.

As Gelain notes, adaptive architecture and agile development are certainly useful; there is a reason Darpa is hiring scrum masters (digital-agility experts). However, the idea of "aerospace engineers being displaced by video game developers" is a leap too far. Having worked on both video games and missile systems, the essential differences between the two are not measured by complexity, but by precision and reliability.

While we work to gain speed and agility, we cannot surrender too much process, documentation and testing. The threshold for a minimum viable product is much higher when the lives of our fighting corps are on the line.

Robert Carlisle
RALEIGH, NORTH CAROLINA

CORPORATE-SPONSORED R&D

Michael Bruno's commentary, "Do Your Research" was enlightening (*AW&ST* April 27-May 10, p. 16). I worked at the Sperry Corp. Research Center from 1977-83. At that time, it was an advantage for corporations to foster such centers when it came to winning government contracts. Near-, mid- and long-term research could possibly pay off in 1-2, 5-6, and 10 years or more, respectively.

But a change in government policy abrogated the advantage of in-house R&D centers. Research activities suffered and in-house funding was dedicated to very short-term development.

To foster the mid- and long-term research essential for true innovation in the A&D sector, the government should supply companies that conduct such research with some kind of proposal-scoring advantage when bidding for government contracts.

William B. Spillman, Jr.
FLOYD, VIRGINIA

Who's Where

Steve Wadey

Eric Born

Mark Millam

Philip Kiel

Tracy Neil

Robert Cabana

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

Richard Peretz has been appointed chief financial officer of Atlanta-based *UPS*, effective July 1. He succeeds **Kurt Kuehn**, who will be retiring. Peretz has been corporate controller/treasurer. **Edward Rogers** has become global director of sustainability.

Steve Wadey (see photo) has been named CEO of U.K.-based *Qinetiq*. He was managing director of the U.K. business of MBDA and group technical director.

John Shannon has been appointed *Boeing* vice president/program manager for the Space Launch System. He succeeds **Virginia Barnes**, who is retiring. Shannon has been the company's International Space Station program manager and was NASA deputy associate administrator for exploration planning.

Eric Born (see photo) has become group president/CEO of of Zurich-based *Swissport International Ltd.*, effective Aug. 1. He will succeed **Per H. Utnegaard**, who will become vice chairman. Born has been CEO of U.K.-based Wincanton and was president for Western and Southern Europe of Gategroup.

Steve Bruce has been named sales director of *Greenpoint Aerospace*, Denton, Texas. He was business development director for U.S. business aircraft for Zodiac Aerospace and held executive sales, maintenance and commercial operations at Embraer.

Mark Millam (see photo) has been appointed vice president-technical of the Alexandria, Virginia-based *Flight Safety Foundation*. He was managing director for safety for Airlines for America. **Christopher Rochette** has become senior manager of events and marketing. Current executives who have been promoted are: **Greg Marshall**, vice president-global programs; **Frank Jackman**, vice president-communications; and **Susan Lausch**, vice president-business operations.

Mike Bianchi has become vice president-maintenance of Kansas City, Missouri-based *Executive AirShare*. He was director of maintenance operations at American Eagle Airlines.

Philip Kiel (see photo) has been appointed president of *Photo-Sonics Inc.*, Burbank, California. He was vice president-operations.

Mark Meader has become vice president-industry affairs for the *American Society of Travel Agents*, Alexandria, Virginia. He was vice president-business development at the Airlines Reporting Corp.

Tracy Neil (see photo) has been named director of marketing of *Pentastar Aviation*, Waterford, Michigan. She was brand manager for service products at Federal-Mogul Motorparts.

Ray Lawrence has been appointed head of the *ULPower Southeast Service Center*, Sandersville, Georgia.

HONORS AND ELECTIONS

Robert Cabana (see photo), director of NASA's Kennedy Space Center, has received the 2015 National Space Trophy from the *Rotary National Award for Space Achievement Foundation*. He was honored for career contributions to the U.S. space program, among them his ongoing efforts on Florida's Space Coast to transition the Kennedy Space Center from shuttle operations to a multi-user spaceport for commercial and government-sponsored missions.

Tony Gay, engine services manager at StandardAero, Augusta, Georgia, has been named to receive the *Aircraft Technical Publisher/National Air Transportation Association* General Aviation Service Technician Award "for his 41 years of providing the highest quality corporate aviation maintenance service." Others to receive awards are: **Jess Romo**, manager of the Van Nuys (California) Airport, NATA Airport Executive Partnership Award for his "efforts to foster relationships between aviation businesses and airport operators"; **Eric Walter**, chief pilot at Bemidji (Minnesota) Aviation Services Inc., Excellence in Pilot Training Award for "contributions in safety, professionalism, leadership and excellence in . . . pilot training"; and **Jeremy Van Dyke**, line service manager at Truman Arnold Companies/TAC Air, Amarillo, Texas, NATA's inaugural Safety First Certified Line Service Professional Award, for "achievements of certified line service professionals demonstrating the positive impact that they have on safety, service and business success."

60%

and growing.

"The great thing about a fact, is that, well it's a fact. We say this because over the past five years, when in a competitive situation, the Trent 1000 has been chosen ahead of the competition 60 per cent of the time and its popularity continues to grow.

In fact, the Trent 1000 has up to three per cent better fuel burn than the competition. A figure that can equate to savings of tens of millions of dollars.

Here's another fact; being part of the most successful family of aero engines in the world, the Trent 1000 has demonstrated its ability to handle harsh environments, including extreme hot and cold conditions. This is no fair weather engine.

With a dispatch reliability of 99.9 per cent and all of the above, the fact is the Trent 1000 is becoming the most popular engine on the Boeing 787."

Iain Dudley, Head of Marketing - Trent 1000

Rolls-Royce

First Take

BEN COOPER/SPACEX

Engineers at NASA and SpaceX are reviewing data from a pad-abort test of the company's Crew Dragon vehicle at Cape Canaveral on May 6, as work continues toward spaceflight with the commercial crew vehicle SpaceX will use to deliver astronauts to the International Space Station. Testing the system that would push the vehicle to safety in a launch-vehicle failure marks a major milestone under the company's $440 million Space Act agreement with NASA, with the expectation that it will fly starting in 2017.

DEFENSE

Dassault has secured its third Rafale export customer in as many months with Qatar placing a €6.3 billion ($7 billion) order for 24 fighters, plus 12 options, on May 4 (see page 12). Qatar Airways reportedly secured additional traffic rights to France as part of the deal (see page 25). In February, Egypt signed for 24 Rafales, and India committed in April to purchase 36.

The U.S. Air Force is shuttering a program designed to identify sources of interference to satellite communications due to cost and performance issues (see page 27).

Saab plans a major upgrade to the JAS 39C/D Gripen's radar, doubling detection and tracking range and giving it the ability to track low-radar-cross-section targets. Developed with

WILLIAM JARDIM

company funds, the PS-05/A Mk. 4 radar retains the mechanically scanned antenna. A prototype flew for the first time in December in a JAS 39D.

The Netherlands, Norway and Poland planned to issue a request for proposals to Airbus for a joint purchase of up to four A330 tankers to provide aerial refueling and strategic transport.

SPACE

The Obama administration is bolstering funding to protect government assets in space in response to anti-satellite capabilities developed by China and other potential adversaries (see page 68).

Out of fuel after four years orbiting Mercury, NASA's Messenger spacecraft crashed onto the far side of the planet April 30. Messenger was launched in August 2004 and entered Mercury's orbit in March 2011, finding evidence of volcanic activity and confirming the presence of water ice in permanently shadowed polar craters.

Blue Origin sent its New Shepard suborbital human spacecraft to an altitude of 307,000 ft. on a vertical-takeoff, vertical-landing launch vehicle from Van Horn, Texas, on its April 30 first flight. The reusable cryogenic booster was lost

BLUEORIGIN

to a hydraulic system failure, but the capsule separated above 200,000 ft. and was recovered by parachute.

Eugene L. Tu was named director of NASA's Ames Research Center, succeeding Simon P. "Pete" Worden, who left the agency for the private sector. Tu had served as director of exploration technology at Ames since 2005.

SpaceX launched TurkmenAlem52E/MonacoSAT by Falcon 9 on April 27 after a delay in part due to increased pressure to resupply the International Space Station. In the first of 11 flights planned this year, Arianespace's Ariane 5ECA launched the French/Italian Sicral 2 military communications satellite and commercial operator Telenor's Thor 7 on April 26 (see page 34).

Lockheed Martin's moves to merge its military and commercial satellite-manufacturing operation and "refresh" onboard technology in its workhorse A2100 bus are on pace to meet 2018 launch dates for the first two commercial satellites the company has sold since 2011. The two-satellite deal with Arabsat and King Abdulaziz City for Science and Technology is part of a $650 million push by Saudi Arabia to modernize its satcom fleet and begin developing its own spacecraft capabilities.

COMMERCIAL AVIATION

Emirates has rebutted allegations by U.S. carriers that it has received at least $5 billion in government subsidies since 2004 and says the coordinated campaign by American Airlines, United Airlines and Delta Air Lines is aimed at stifling competition (see page 24).

Bombardier CSeries launch customer Swiss International Air Lines is confirmed as the launch operator for the initial 110-seat CS100 version, slated to enter service in the first half of 2016. The Lufthansa Group airline replaces Malmo Aviation, which withdrew as launch operator last year, citing CSeries delays.

Norwegian Air Shuttle will apply to the U.S. Transportation Department for a foreign air carrier permit for its U.K. airline once it obtains an air operator certificate from U.K. authorities, CEO Bjorn Kjos says, reiterating his frustration over the delay in receiving a Transportation Department permit for Ireland-based subsidiary Norwegian Air International.

CFM International has begun flight-testing the Leap-1B engine for the Boeing 737 MAX, laying the foundation for flight trials of the new airliner in

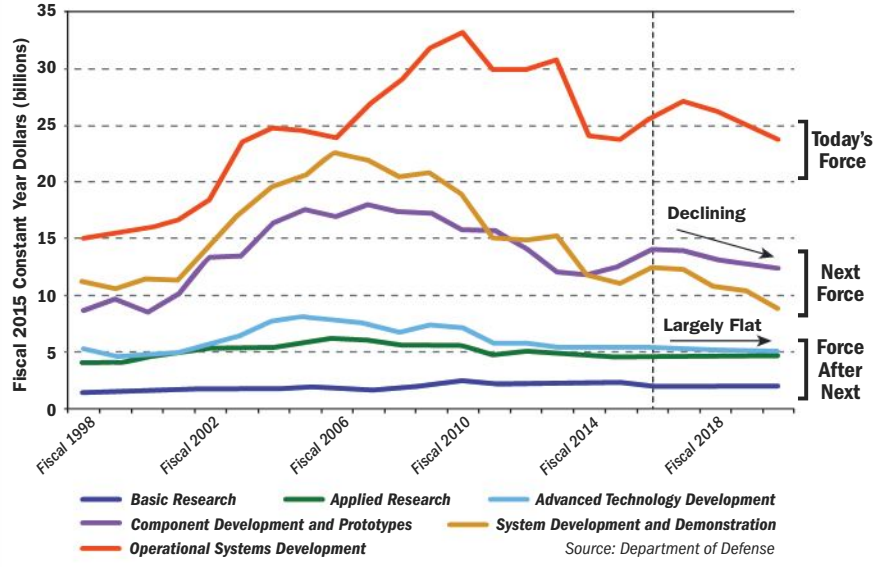
CFM

2016. The engine flew for 5.5 hr. in the No. 2 position on General Electric's 747-100 testbed at Victorville, California, on April 29.

By 2018, airlines may be able to use ground-based augmentation systems (GBAS) for satellite-based Category 3 approaches to a 50-ft. decision height or automatic landing, the FAA says, offering a lower-cost alternative to instrument landing systems. A growing number of carriers are using GBAS for Cat. 1 approaches with a 200-ft. decision height at a handful of airports.

The FAA has partnered with CNN, PrecisionHawk and BNSF Railway to research expanding small unmanned-aircraft operations for newsgathering, agriculture and track monitoring beyond the limits of the agency's proposed rule for UAVs under 55 lb. This includes allowing flights over people and beyond line of sight of the operator.

Pentagon's Shrinking New Product Pipeline



Source: Department of Defense

The U.S. Defense Department is concerned that, as budgets reduce, it is spending too many R&D dollars on upgrading current systems and not enough on developing new systems and technologies for the future.

BUSINESS AVIATION

Airbus will assemble its E-Fan electrically powered light aircraft in the southern French city of Pau, close to partner Daher. Subsidiary Voltair plans to produce a family of two- and four-seat aircraft. Airbus is investing €20 million ($22.3 million) in the two-seat E-Fan 2.0, for entry into service by late 2017 or early 2018.

AIRBUS CONCEPT

Bombardier plans to slow production of Global 5000/6000 business jets from its current rate of 80 a year, citing market softness in Latin America, Russia and China. The Canadian company also plans an initial public offering of a minority stake in its rail business.

Died: Jim Wright, a former U.S. House speaker and author of the Wright Amendment, a law restricting traffic at Dallas Love Field that was repealed last October. He was 92 (see page 23).

70 YEARS AGO IN *AW&ST*

As World War II came to an end in Europe, battles continued to rage in the Pacific. In our May 1945 issue, Aviation Week, then a monthly called *Aviation*, published an extensive analysis of Japan's workhorse fighter, the Mitsubishi A6M Zero.

Read the original article and learn about other historic events in aerospace and defense at: **AviationWeek.com/100**

By Antoine Gelain

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

COMMENTARY

Dassault's Secret Sauce

Outlier military aircraft OEM shows how it pays to be stubborn

In this column last year, I wrote "[Dassault Aviation's] Rafale is a story of stubbornness and manipulation," noting that 28 years after its official launch, the aircraft had not won a single export order (*AW&ST* Feb. 3/10, 2014, p. 16). But within the last two months, three orders have been announced for close to a total of 100 aircraft to Egypt, India and Qatar, and suddenly the future looks bright. So what's happening?

DASSAULT

Yes, Rafale is a story of stubbornness, but sometimes it pays off. Rafale also is a story of manipulation, but one must acknowledge that political manipulation is part of the game. And so these recent commercial successes remind us of the singularity of the international defense market: unpredictable, highly political, and with economic and industrial stakes so big that it can take a decade or more to close a deal.

It also reminds us of the singularity of Dassault as a corporation. Everything that has been happening to the company during the past half-century seems to defy rational analysis and common business sense: It took 30 years for the company to sign its first export order for the Rafale, even though one of the main design drivers of the aircraft was to make it light enough to be exportable (unlike the much heavier Eurofighter). Which CEO today would dare to show up in front of his shareholders and present a business plan in which the first export order would only happen a couple of decades down the line?

Meanwhile, compared to its giant American counterparts such as Boeing or Lockheed Martin, Dassault—with its meager $5 billion of annual revenues—looks incredibly small for an aircraft OEM capable of designing and producing what is widely recognized as the best alternative to U.S. combat aircraft. And in spite of all the industry consolidation in Europe during the last two decades, Dassault has remained fiercely independent and barely grown in size. Yet the company is consistently profitable, thanks primarily to a tight financial discipline and its Falcon executive jet business, which accounts for almost three-quarters of Dassault's annual sales.

There is certainly something anachronous about the company: the level of secrecy it cultivates, the way it seems to go against the tide of globalization and consolidation, and the way it is able to rise from the ashes as the recent export orders tend to indicate.

The mystery and fascination surrounding Dassault is not new. In a 1973 Rand Corp. report commissioned by the U.S. Air Force, Robert Perry writes extensively about the company's paradox. He wrote: "That Dassault is consistently able to create and produce high-performance aircraft comparable to and competitive with those of the United States is almost paradoxical, given the resources of the company and the international environment in which it operates." Trying to come up with some rational explanation for such success, he concluded: "In many respects, the uniqueness of Dassault appears to be explainable mostly in terms of the company's people, principles, policies and practices."

What is certain is that behind what may seem old-fashioned or unorthodox practices, the company has always been at the forefront of technology, thanks to a consistent and evolutionary approach to innovation. This has allowed Dassault to capitalize on every prototype built; and it has built a lot of them.

These days, people make a big deal out of data analytics but it seems Dassault has been harnessing the power of data for many decades, as its heavy reliance on prototype-building has given the company unprecedented insights into what it takes to develop and build a fighter aircraft. For that reason, Dassault's cost estimates are believed to be very precise, with no more than a 10% margin of error, compared with U.S. programs' typical 40-80%.

Overall, it would be easy to characterize Dassault's recent commercial revival as a stroke of luck and possibly the last stand of a company that has been living off a decades-old business philosophy and a network of political and commercial connections whose relevance and power have been weakening slowly. Blame the forces of globalization and modern capitalism.

Yet there is something uplifting about an organization that so consistently manages to defy the odds, challenge commonplace analysis and so expertly balance craftsmanship and high-tech, conservatism and innovation. Dassault might even give us a clue about how to develop a sustainable corporate model in the 21st century.

After all there is a lot to learn from outliers, and possibly a lot to gain from being one. If we only try to replicate what the majority does, we will remain merely average. And average is the one thing a combat aircraft cannot afford to be.

By Michael Bruno

Senior Business Editor
Michael Bruno blogs at:
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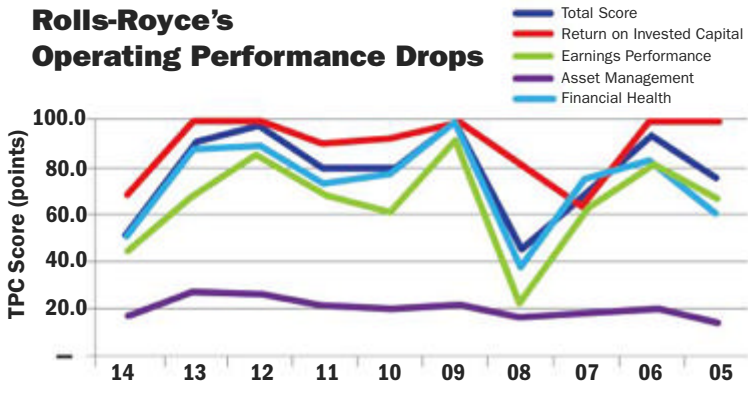
COMMENTARY

Great Expectations

As conditions change in A&D, look for new faces setting new parameters

To read the formal press release one way, John Rishton is going out on top. After becoming CEO of Rolls-Royce in April 2011, profits rose 69%, the British engine maker's order book grew 24%, and the share price climbed 63%.



Source: Aviation Week Top-Performing Companies (TPC) Study

No wonder, then, that at age 57 he is apparently electing early retirement. "We respect his decision to retire after more than four years of dedicated service," the company said April 22. So why did stock traders cheer, sending the price up 4% that day? Consider it a case of managing expectations—old and new.

Last year, for the first time in a decade, revenue at Rolls dropped. Sales fell by 6% to £14.5 billion ($21.9 billion) while profits sank 8% to £1.62 billion, compared with 2013 results. Last November, Rolls fired its CFO (*AW&ST* Nov. 17, 2014, p. 17). In February, Rishton and the company told analysts to expect lower profits in 2015, £1.4-1.55 billion, and revenue of £13.4-14.5 billion.

Moreover, the situation has been building, as illustrated by Rolls's results in Aviation Week's Top-Performing Companies study this year. TPC ranks publicly traded aerospace and defense (A&D) contractors in composite scoring of four equally weighted performance categories that place significant emphasis on operating excellence. From return on invested capital, to earnings performance, asset management and financial health, Rolls's results were worsening in a way not seen since the worldwide financial crisis of 2008 (see chart).

Not surprisingly, by April, shareholders were anxious for encouragement. Then came word of the leadership change: Warren East, a former CEO of semiconductor company ARM Holdings, will succeed Rishton come July 2. But some analysts immediately started raising recommendations anyway.

"We think there are opportunities for new CEO Warren East to focus on when he takes the helm in July," Sanford C. Bernstein analysts said. "Three areas in particular we would like to see included are: portfolio optimization, resetting expectations and operational improvements."

RBC Capital Markets analysts also were seeing bluer skies, starting with the potential for better communication with Wall Street and other investor communities.

"As CEO, we think Warren East can continue . . . improving the communication of Rolls-Royce with investors," the RBC analysts said. "During his time at ARM, East built a reputation of being straightforward, and not embellishing the situation. He can also help reassure investors regarding capital deployment, where Rishton's flirtation with Wartsila has raised the risk of dangerous mergers and acquisitions. He can also carry on Rishton's focus on cash and costs, but maybe adjust the cheesy '4Cs' branding."

The latter refers to Rishton's talking points about "customer, concentration, cost and cash" which—while practically indisputable as priorities in traders' minds—now were seen as increasingly hollow as revenue and profits slipped. But the analysts know there are still forces beyond any CEO's control that will challenge East and his team.

"He can't change the oil price, and we think the impact on the marine division of the price decline is likely to be more negative than anticipated," RBC said. "He also can't do much about the [revenue] mix change in civil, though he can improve the guidance on this issue.

"We suspect that margin expectations for Civil Aerospace in 2016-17 are at risk due to the decline of the linked A330 Trent 700 while the unlinked A350 Trent XWB is ramping up," RBC continued. "If Airbus goes for a reengined A380, with Rolls as the engine provider, this will likely require a further adjustment to research and development and cash."

In other words, according to Bernstein, "the Civil Aerospace business still faces fundamental challenges that will prevent the margin and cash flow improvement over the medium term."

Though shareholders are welcoming Rishton's decision to leave, many must know underlying conditions remain a challenge. While not a new phenomenon to publicly traded companies, the A&D sector is seeing more examples of this lately. Witness last year's abrupt departures of Louis Chenevert from United Technologies, Linda Hudson from the U.S. arm of BAE Systems, John Jumper from Leidos, and Gordon Walsh and Steven Gaffney from DynCorp. Then there were this year's dramatic turnovers of the CEO, CFO and others at Bombardier.

A&D cognoscenti know the sector is set for more change over several years. Almost certainly, that includes the corner offices.

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

COMMENTARY

Doubling Down

Will two as one succeed?

It's an old saw: How do you make a small fortune in aviation? Start with a big one. But Mason Holland is determined to turn that truism on its head. He began by losing a small fortune in aviation, and is working to make it back big time, with something failed but promising.

An entrepreneur of the first order, Holland (photo) co-founded and is board chairman of Benefitfocus Inc., a fast-growing, publicly traded software company that manages insurance options for corporate employees, and he has several other unrelated businesses as well. He took up piloting in the 1990s, bought a Cessna 182 and then upgraded to a Cirrus SR22 in 2002. Soon he became enamored with the performance, price and twin-engine safety of the highly promoted Eclipse 500 very light jet (VLJ) and put down a "seven figure" deposit on one. But he never took delivery; the planemaker went bankrupt and his million dollars disappeared.

In the legal proceedings that followed the Chapter 7 filing, Holland assembled a small group of investors that in 2009 acquired all of Eclipse Aviation's assets for $20 million in cash and $20 million in notes. The failed company had invested in excess of $1 billion in the program and had delivered 260 aircraft when its doors were padlocked. So Holland's new Eclipse Aerospace gained ownership of a certificated jet—a Collier trophy winner, at that—along with all production tooling and its Albuquerque, New Mexico, facilities for pennies on the dollar.

"It was a beautiful transaction," he says, adding, "I ended up with more than one plane."

Initially, the reborn company served primarily the MRO function of servicing the existing fleet. It also assumed the task of upgrading aircraft to the standard originally intended, but which few of those delivered actually met. For example, the aircraft couldn't fly coupled approaches, the tires wore out after a few landings and the air conditioning was weak. The ice protection system was not certifiable in its original configuration, so flight into known icing (FIKI) was prohibited.

The company delayed restarting production of new aircraft because the great recession that helped bring down the original company had also put the brakes on new light jet sales; so many operators were trying to unload their aircraft that the used jet market was choking with almost-new inventory.

"My greatest challenge was to grow the company slowly enough to allow the country time to recover economically," Holland says.

ECLIPSE AEROSPACE INC. PHOTOS

He was satisfied that fiscal and market conditions were improving enough to justify a slow production restart in 2012. The aircraft, upgraded with the Avio 2.7 integrated avionics system, FIKI approval, anti-skid brakes, dual flight-management systems, optional weather radar, autothrottles, a traffic alerting system, Class B TAWS and synthetic vision, among other things, is marketed as the Eclipse 550 (lower photo) and sells for about $3 million.

Holland says the company expects to deliver 12-14 aircraft this year, repeating 2014's record and then increasing the rate in 2016. While he's hesitant to forecast an output target, he notes that NBAA statistics show 70% of all business aircraft trips are 750 nm or less and involve three or fewer passengers. Thus, the Eclipse 550 "fits that bill as the most efficient way" to meet the majority of business aviation missions, Holland maintains.

Beyond that, he says the diminutive jet—it measures 30 ft. nose to tail, has a 38 ft. wing span, and accommodates two in the cockpit and four passengers in the snug cabin—could serve as a super-efficient trainer. In fact, the company has been in regular discussions with the U.S. Air Force and, he believes, the Eclipse will be operating as a military trainer in "the next year or two." He says it will save the Air Force $1 billion a year in operating costs.

While no dramatic upgrades are in store for the twinjet, Holland says giving it autoland capability or operating unmanned is worth consideration.

But the most significant development to the program involves its ownership. Holland announced in April the creation of ONE Aviation, a new company in which Eclipse is a subsidiary along with Kestrel Aircraft, a single engine, all-composite turboprop development program begun in 2002 in the U.K. as the Farnborough F1 and headed by Alan Klapmeier. A cofounder of Cirrus Aircraft, Klapmeier is CEO of the new company while Holland serves as chairman. The two men have been good friends since Holland took delivery of his SR22 more than a decade ago.

Holland says Klapmeier is "the perfect, perfect leader for this company" and "the guy that should be running this day to day." Klapmeier will provide the vision, and "I understand financial structure and how to get us there," Holland says.

In addition to certifying the Kestrel K350 in the next three or four years, Holland says a larger version of the Eclipse is possible, as are acquisitions of existing aircraft.

It's a new dawning for both programs, and "I'm just ecstatic," Holland says. "This is way cool."

By Jens Flottau

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COMMENTARY

Buying Time, Losing Time

Lufthansa's proposed arbitration in its pilot dispute delays true restructuring

As the history of the air transport industry tells us, airlines don't disappear suddenly. In most cases it takes years or even decades until a slow, then accelerating decline leads to bankruptcy or—with more luck—a takeover. The demise of an airline also has never been due to a single event. Looking back, there always have been milestones, missed opportunities and bad decisions that exacerbated an existing negative trend.

LUFTHANSA

Many legendary names have disappeared, particularly in the U.S. where Braniff, Eastern, Pan American and Trans World are among those gone. But those outright market exits have been the exception rather than the rule. More commonly, airlines have slowly lost their former status and become smaller, less significant players in the market. In the best of circumstances, they found a niche. Swiss is a good example of a highly profitable airline that has never had the kind of colonial ambitions of Swissair, but is focused on the needs of the local market.

Many midsize airlines have had to scale back their hubs because they were unable to compete. It has happened to European carriers like Alitalia and Iberia and can be seen happening at Malaysia Airlines where a new business plan foresees shrinking the long-haul network and fleet.

Lufthansa is not in the TWA, Pan American (or Sabena) category, but one of the once-dominant airlines has entered a long downhill course. Low-cost carriers have grown so much in Europe that Lufthansa has given up its point-to-point network and only flies short-haul routes when they are needed to feed hubs. Many of its long-haul routes—flown by aircraft such as the Boeing 747-8 (shown)—are also unprofitable, not due to competition from Gulf carriers, but because its unit costs are way too high.

Earlier this month, Lufthansa came to an important crossroads but seemed to take the wrong turn. The airline, still in shock-recovery mode after the deliberate March 24 crash of an Airbus A320 of subsidiary Germanwings, offered pilot union Vereinigung Cockpit (VC) far-reaching arbitration on all outstanding issues including early retirement, pension reform, pay, work rules and career planning.

The decision is a stark reminder of what happened at Air France last year. After a devastating pilot strike and facing intense political pressure, management dropped plans for an aggressive expansion of the Transavia low-fare division, leaving cost issues largely unresolved at the legacy airline. A long-term solution (lower unit costs) was traded for short-term benefit (no more strikes).

That is more or less what is now happening at Lufthansa. CEO Carsten Spohr should be admired for not giving in to VC demands so far, but it now seems he has lost faith. The Germanwings crash has had a traumatic effect on the company as a whole, but also on the CEO. Another strike is more than he could take.

But Lufthansa's cost issues need urgent attention, most importantly a multibillion-euro pension shortfall that has been aggravated by stubbornly low interest rates. By contrast, arbitration in such complex disputes will be a long and tedious process that likely will not lead to any compromise before the end of 2016. That agreement almost certainly will be insufficient to bring Lufthansa back to a sustainable cost level. Its unit costs are up to 40% too high on short-haul flights and 20-30% too high on long-haul services. No arbitration compromise will bring those expenses into line.

Lufthansa had to absorb more pain even if it meant more strikes. In arbitration, it will lose valuable time to rescue the legacy portion of its business. The most likely result will be a carrier that is shrinking in size with all the long-term consequences in the cockpit and cabin. First officers at Lufthansa will now likely spend decades in the right seats; many may never become captains. Layoffs, previously unknown, have become more likely, too.

The only good news from management's view is that arbitration will force pilots into a non-strike mode at the same time as the Eurowings low-fare brand is developing into a 100 aircraft-plus operation. That is the one key difference from the Air France case: German pilots have little to say against the creation of a separate low-cost carrier so long as the Lufthansa brand is not used.

If past is prologue, one has to be skeptical about the ability of Lufthansa or any other legacy carrier to build a successful low-fare division, although Eurowings will have a big cost advantage over the hub-and-spoke operation and therefore a better chance of survival. But the serious threat continues that another great airline brand will fade away because management and employees have been unable to implement meaningful reform.

By Graham Warwick

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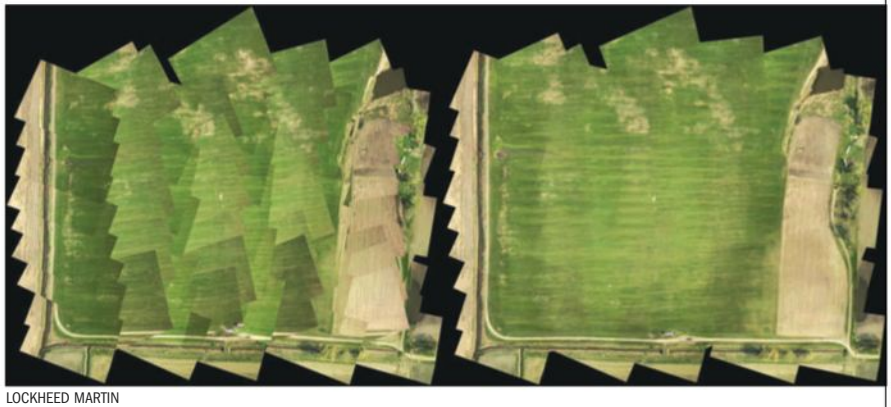
COMMENTARY

Adjacent Acorns

Will early engagement in the emerging civil UAS market lead Lockheed Martin in new commercial directions?

A toehold in the commercial unmanned-aircraft business is taking Lockheed Martin in interesting directions, but where this small-scale exposure to a fast-growing market might take the defense giant in the long term is hard to guess.



LOCKHEED MARTIN

Spearheading its entry into the civil market is the Indago quadcopter small unmanned aircraft system (UAS), which became a Lockheed product when the company acquired developer Procerus Technologies in January 2012. But the engagement goes further, with other business areas working with farmers to speed the processing of images from UAS and providing information on unmanned-aircraft flights to general-aviation pilots.

Trials of the 5-lb. Indago already have seen Lockheed work with Australian operator Heliwest to use the quadcopter to support firefighting by flying at night when manned aircraft operations are banned for safety reasons. Heliwest also has used Indago for shark-spotting on the Western Australia coast, and in April deployed two of them to Vanuatu to help map damage after Cyclone Pam. In the U.S., Indago has been teamed with the Lockheed/Kaman K-Max unmanned helicopter in a firefighting demonstration.

Now Lockheed has partnered with nonprofit Project Lifesaver International to equip the quadcopter with a system that enables first responders to find people with cognitive disabilities who wander from their homes and become lost. Equipping the Indago with a lightweight antenna and receiver that can locate tracking bracelets provided by Project Lifesaver should dramatically extend the search range compared with the ground-tracking equipment now used.

Project Lifesaver CEO and founder Gene Saunders says studies show that about half of all autistic children will wander off at some point, while about 60% of Alzheimer's sufferers will become lost. The organization provides equipment and training and has enabled almost 3,000 rescues since forming in 1969. Saunders says its system has cut search times by 95% to an average of 30 min.

A wristband puts out a once-per-second FM pulse that can be detected by the direction-finding hand controller over a distance of only around 1 mi. Fitted with an antenna and receiver, the Indago can operate up to 3 mi. from the controller and, flying at 400 ft. altitude, pick up the wristband signal at ranges of 5-7 mi.

Small UAS have another growing use: gathering imagery. Lockheed has employed the aircraft to develop a more efficient algorithm to assemble thousands of pictures into a single high-resolution photo for agriculture and other purposes. Bundle adjustment, the conventional algorithm used to mosaic images, can handle tens or hundreds of pictures but can take days, says Lockheed.

UAS like Indago are cheaper to use than manned aircraft, but are limited to 400 ft. and photographing a 250-acre field from that altitude generates thousands of narrow field-of-view images that must be mosaicked. They do not match perfectly because of aircraft motion, and so need to be adjusted—orthorectified—to produce a single high-resolution photograph for analysis. "Bundle adjustment does not work," says systems engineer Mark Pitt. "There is too much information for the software."

Mosaicking software efficiently turns raw images of a field (left-before) into a single photograph (right-after).

Bundle adjustment identifies common features called ground control or tie points, in overlapping images. But the exact locations of those points on the ground are not known, so the algorithm estimates the three-dimensional coordinates as well as camera position and orientation, and varies those conflicting parameters through many iterations in an effort to minimize the georegistration errors.

Approached by an agricultural firm facing the problem of geomosaicking thousands of images of a farm, Lockheed developed an algorithm that makes the process more efficient by separating the problem into two parts: adjusting just the ground control points and then the camera parameters. "It converges very quickly," says Pitt. "That surprised us, so we tried it on several data packages, and it works." Tests have included imagery data provided by the Indago team.

These are small activities for an entity the size of Lockheed but as the civil market grows, the company is seeing burgeoning commercial interest in technologies it is developing for the military, including hand-launched UAS with fuel-cell propulsion that can be deployed quickly to remote areas and launched rapidly to stay aloft for extended periods.

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COMMENTARY

Natural Selection

Who will survive to take on JSF?

Qatar's order for the Dassault Rafale—whose export orders have soared from zero to 84 in three months flat—is part of a shift in the fighter business that began just over two years ago, when the Swedish government issued a development contract for the JAS 39E Gripen (see page 12).

BILL SWEETMAN/AW&ST

Saab subsequently locked in a co-development agreement with Brazil, while the F-15 and Eurofighter Typhoon lost to the F-35 Joint Strike Fighter in South Korea. The Advanced Super Hornet has languished, with nothing but rhetorical support from the U.S. Navy. Are we headed for a three-way contest among Western fighters?

Gripen (see photo) and Rafale are now free from the "F-104S syndrome": a fighter customer's fear of being the last purchaser in a program, stuck supporting aircraft that the rest of the world has retired, as happened to Italy when it bought F-104s in the late 1960s.

Whether Typhoon can shake off that curse depends largely on two linked decisions: the United Arab Emirates' choice of a new fighter, and the new British government's strategic defense and security review (SDSR). The link was implicit when Eurofighter and the UAE broke off talks in late 2013. "There's no point talking about price," the customer seemed to be saying, "as long as your partner governments are waffling about paying for the radar and weapon upgrades that are already funded on Rafale."

Some key developments have been funded since then—integration of the Brimstone close-support weapon was pointedly announced at the IDEX show in Abu Dhabi—but the SDSR needs to secure Typhoon's future with the Royal Air Force. The clock is ticking, because parts for the last Typhoons on order already have been manufactured.

The clock is ticking, too, for some customers, including the UAE, Kuwait and Bahrain: Sweden does not sell such weapons to those nations, and they are not cleared for the F-35, so the Typhoon could be the only modern alternative to the Rafale. Sole-source negotiations are not a place where anyone likes to be. Eurofighter has been using a "buy now or pay more later" message with Saudi Arabia, which is contemplating a second tranche of Typhoons.

Typhoon needs a full commitment to an upgrade of its active, electronically scanned array radar, decisions by the partner nations that upgrades will continue (which the U.K. will have to weigh against its F-35 plans) and what one observer calls "better joined-up diplomacy"—harmonized relationship-tending by industry, government trade and diplomatic organizations, and the military.

Outside the Middle East, Saab's double offensive is a factor: the Gripen C/D for the pre-2025 market and the E/F after 2023, when the first export slots are open. Somewhere in Sweden is a stockpile of low-hours A/B versions, probably in the dozens, which can be rebuilt into C/Ds.

F-35 candidate nations are on the Dassault and Saab target lists. Finland is a target for the JAS 39E/F: a more promising one than it was in the past, thanks in part to Russian President Vladimir Putin, whose actions have encouraged military collaboration between the Nordic cousins. Both Dassault and Saab are active in Belgium. Saab considers nations currently in the F-35 program a waste of scarce ammunition, but Dassault is present in Canada, ready to take advantage of any change that follows this October's election.

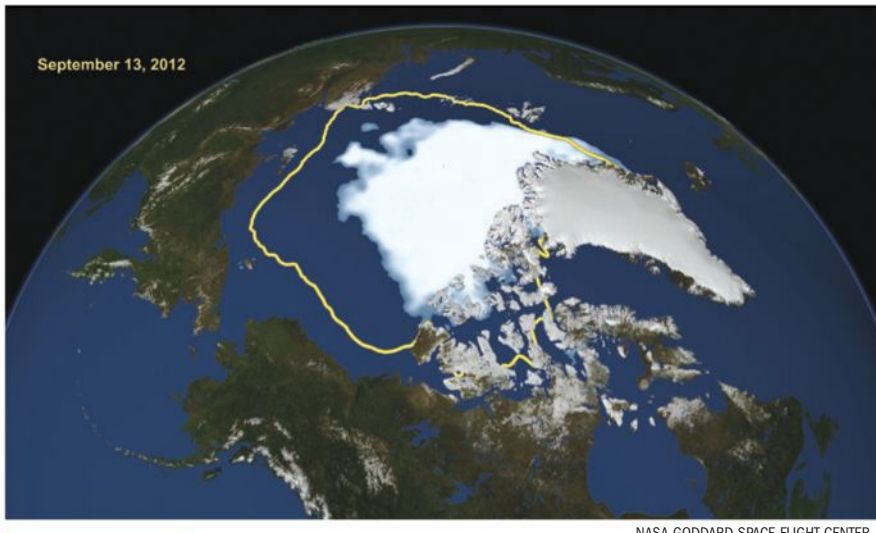
All three European fighters are active in Asia-Pacific markets, but Saab has two advantages: cost (none of the eligible customers in the region is rolling in cash) and a foothold in Thailand, which is building a networked air defense system around Gripens and Saab 340 airborne early warning aircraft.

Both Rafale and Gripen would be in a stronger position if Typhoon continues to lag—and they are showing willingness to dispute the orthodoxy that anything except the so-called fifth-generation jet counts as second-rate.

New VHF radars and infrared search-and-track technology are at least nibbling at the advantages of a costly low-radar-cross-section design, the Europeans argue. Saab leaders noted early this month that Gripen's new jamming suite (*AW&ST* May 26/June 2, 2014, p. 66) reflects the customer's requirement to survive inside the "red-bubble" danger zone of the latest surface-to-air missile systems, something that stealth dogma considers unique to the F-22 and F-35. Capabilities that are fighting for a place in JSF's Block 4 configuration—digital close air support, standoff optical reconnaissance, the MBDA Meteor air-to-air-missile and anti-ship missile carriage, for example—are already in place on European products.

It's not the scenario that Lockheed Martin painted for prospective industrial partners as recently as a couple of years ago, where every rival disappears from the scene by 2024. But the real-world picture looks like keeping needed competition in the market.

Check 6 *Bill Sweetman and other Aviation Week editors discuss the fighter market's twists and turns in the latest Check 6.* **AviationWeek.com/podcast**



NASA GODDARD SPACE FLIGHT CENTER

By Frank Morring, Jr.

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COMMENTARY

Changing Climate

Some lawmakers say anti-science ideology threatens NASA support

You have to get up high to see how bad it is. Flying over the North Pole in September a few years back, en route from Washington to Beijing, there was open water as far as the eye could see. But such anecdotal evidence that the Arctic sea ice is retreating is nothing compared to the wealth of data gathered over the past 30 years by a fleet of polar-orbiting spacecraft, most of them developed by NASA.

Those spacecraft show a dramatic shrinkage in the seasonal ice since 1979 (see map). Last year a freighter carrying ore from Canada to China made the first commercial voyage without the aid of icebreakers through the long-sought Northwest Passage, which the satellite imagery shows was open at the end of the summer as far back as 2012.

Space measurements quantify the changes in the polar ice caps as the average global temperature rises, but nature is more complicated than that. The extent of sea ice off Antarctica has actually increased slightly in recent years, which NASA scientists attribute to the dramatic differences between the shallow Arctic Ocean, the deep and stormy Southern Ocean, and the thick ice cap covering the land mass at the South Pole.

Spacecraft are essential in understanding the complex natural forces at work as the climate changes, including the effects of greenhouse gases produced by burning fossil fuel on those changes. The data can help politicians decide how to deal with the causes and effects of the change. But it is only data. It is not ideology, a fact that seems to have been forgotten in the debate over NASA funding this year.

The issue has been simmering along for years, as the oil companies and other fossil-energy interests have done their best to keep information linking global warming and fossil byproducts out of the public eye (Google the name Rick Piltz for more on that sorry tale). It broke into the open in a particularly nasty way on April 30, when the House Science Committee voted to cut NASA's request for Earth-science research and space missions from $1.947 billion in fiscal 2016 to $1.45 billion.

Led by Chairman Lamar Smith (R-Texas), the panel's Republican majority has been arguing that NASA should focus on exploring space, and leave climate research to the Environmental Protection Agency, National Oceanic and Atmospheric Administration, and other agencies. Democrats on the panel saw it differently.

"Majority's bill cuts Earth science by over $320 million," said Rep. Eddie Bernice Johnson of Texas, the ranking Democrat on the committee. "Earth science, of course, includes climate science. It should come as no surprise that the majority wants to cut funding for a field of science where they are scared of the answers the scientists give."

Johnson and her Democratic colleagues introduced a ream of letters from U.S. academic, scientific and industrial organizations objecting to the Republican move, and the White House weighed in in hopes of persuading the Senate to restore the funds.

Some members of the panel—from both sides of the aisle—agreed that the technology developed for space applications can be as valuable as the economic benefits of cheap energy or federal spending reductions, regardless of how they affect political priorities.

"We're living off the legacy of our parents and grandparents, the progress that they made," said Rep. Ami Bera (D-Calif.), a physician who represents drought-stricken Sacramento County. "And when we're looking at budgets, it's not just the absolute number. We're also looking at where we make our strategic investments, because there is a return on those investments. So the investments we made in the '50s and '60s in aerospace and space technology absolutely grew our economy."

In the end majority rule prevailed, pressed as on so many issues lately by the right wing of the GOP membership. The rancor expressed by Johnson, Smith and some other panel members in the process has become increasingly common on what was once a fairly collegial legislative committee, dealing with an issue—the space program—that has traditionally enjoyed support across the political spectrum.

"NASA's always been a bipartisan endeavor, and part of the reason for that is NASA's always had bipartisan detractors," warned Rep. Donna Edwards of Maryland, ranking Democrat on the science panel's space subcommittee. "By turning this process into a distinctly partisan one, the majority is risking a delicate balance of support that sustained NASA for the last 50 years."

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COMMENTARY

Nuclear Standoff

Senator pushes back on need for long-range missile

The Air Force's plan for the nuclear-capable Long-Range Standoff (LRSO) weapon to replace the Air-Launched Cruise Missile faces a formidable foe on Capitol Hill—Sen. Dianne Feinstein (D-Calif.). The Pentagon has asked for $36.6 million in research funding for LRSO in fiscal 2016, at a time when the program is about to start. Over five years, the government expects to spend $1.8 billion on it. But Feinstein says that is only half the anticipated outlay. The initiative is driving another pricey life-extension program at the Energy Department for the W80 warhead that would ride on the missile, which is also projected to cost $1.8 billion through fiscal 2020. And Feinstein, the top Democrat on the committee that funds the Energy Department, says LRSO is competing with funding for nuclear nonproliferation programs. She questions the need for it, given the arsenal of gravity bombs, submarine-launched ballistic missiles (SLBM) and intercontinental ballistic missiles (ICBM).

REUTERS/LANDOV FILE PHOTO

'We have enough nuclear weapons in this country.'

—SEN. DIANNE FEINSTEIN

Hans Kristensen of the Federation of American Scientists explains that the LRSO serves as an "in-between weapon" providing flexibility in areas where the U.S. would not want to send a stealth bomber or where the use of an SLBM or an ICBM would escalate the tension. Defense Secretary Ashton Carter and Army Gen. Martin Dempsey, the outgoing chairman of the Joint Chiefs of Staff, support the advanced cruise missile—to maintain the U.S. nuclear deterrent during an era when air defenses are improving globally. Carter says he hopes the U.S. can fund both the missile and nonproliferation programs. Feinstein, however, is jaded about repeated cost growth on nuclear programs. "I'm going to have a very hard time voting for it," she says. "We have enough nuclear weapons in this country."

TRY, TRY AGAIN

Debate over this year's NASA authorization bill is more politically charged than in past sessions, but the lawmaker who heads the House committee that funds NASA is trying to sell his colleagues on legislation he says would shield NASA from partisan winds. The bill, sponsored by Rep. John Culberson (R-Texas), would create a 10-year term for the NASA administrator to allow the agency's plans to outlast any one president and enable NASA to stick with long-range efforts. There would be a board of directors for NASA that would be appointed by Congress and oversee the agency the way the National Science Board governs the National Science Foundation. And the bill would set up a multiyear procurement authority similar to that used at the Pentagon.

The congressman offered the legislation during the last two sessions of Congress, but according to *Space Policy Online*, it has yet to pass. It was not included in the fiscal 2013 NASA authorization bill, which itself never became law. Culberson had support from other top Republicans, who controlled the House of Representatives at the time. That is true again. Rep. Lamar Smith (R-Texas), who heads the House Science Committee that oversees NASA, is a co-sponsor. But it is worth noting that the proposal is not included in the version of the NASA authorization bill for fiscal 2016 and 2017 that Smith's committee passed April 30.

NO LOVE OF DALLAS

Jim Wright, a Democrat who served 34 years as a congressman from Fort Worth and eventually rose to speaker of the House has died at 92. The cause was not disclosed. In aviation circles, Wright is known for a law restricting traffic at Dallas Love Field that shackled low-cost carrier Southwest Airlines for years. The Wright Amendment was aimed at protecting still-new Dallas-Fort Worth International Airport, American Airlines' base, when the U.S. deregulated airline routes and fares in 1978. Passed by Congress in 1979, it banned most commercial flights from Love Field, the home of upstart Southwest, to all but Texas and the four contiguous states. A handful of other states were added over the years before the law was finally repealed last October, although other federal restrictions on Love replaced it (see page 47). So effective was Wright in securing various federal advantages for his hometown, President John F. Kennedy once quipped that Fort Worth was "the best represented city" in the U.S. But in 1989, barely two years after he reached the pinnacle in the House, Wright was driven from office in an ethics scandal that the Capitol Hill newspaper *Roll Call* said many students of Congress regard as "the crossing-the-Rubicon moment for the reflexive partisanship and combative incivility that define the Capitol today." The move to oust Wright was led by (then-Rep.) Newt Gingrich (Ga.) who, the paper said, "used the scandal to transform himself from a backbench gadfly into the leader of a younger and more confrontational generation of House Republicans."

Dead End

The campaign against Gulf carrier expansion shifts tactics, but with limited results

Jens Flottau Frankfurt and Madhu Unnikrishnan Las Vegas

U.S. and European airlines have put the issue of alleged subsidies for the Big Three Gulf carriers—Emirates, Etihad Airways and Qatar Airways—high on the political agenda. But as things stand now, it is unlikely that lobbying campaigns will have any serious effect on either side of the Atlantic.

Only weeks after the launch of a U.S. publicity effort, carriers and allied groups that have alleged the Gulf airlines are subsidized and protested their expansion in North America are toning down their rhetoric, subtly changing the message from one of direct opposition to one that merely seeks compromise.

Lee Moak, whose organization Americans for Fair Skies has been among the most emphatic in its opposition to U.S. expansion by Emirates, Etihad and Qatar, now says his organization just wants the U.S. government to discuss a "trade dispute" with the governments of the United Arab Emirates (UAE) and Qatar. "We'd like that in a simple way," he said, speaking at the CAPA Americas Summit in Las Vegas April 28. "They [the Gulf carriers] are lobbying against us having that conversation." This sentiment is echoed by Will Ris, American Airlines' senior vice president of government affairs, and Ben Hirst, Delta Air Lines' chief legal officer.

But despite the rhetoric of "returning to the negotiating table," the issue is not that simple, say some industry insiders. In order for the U.S. to begin consultations provided for under the open-skies treaties, merely proving subsidies is not enough. Instead, airlines have to prove damage from those subsidies, says Jim Callaghan, general counsel for Etihad. And freezing capacity at the Jan. 28 level before consultations begin, as the CEOs of American, Delta and United Airlines have urged, would abrogate the open-skies treaties. Emirates has since announced new service to Orlando, and Qatar Airways plans to introduce daily flights to Los Angeles, Boston and Atlanta next year.

Emirates Airline President Tim Clark, who has always strongly denied being subsidized, released a more detailed response two months after the allegations were first made public. He accuses his airline's competitors of merely trying to limit competition.

"Emirates does not receive and never has received any form of subsidy from the UAE government," the company states in its government affairs newsletter *Open Sky*. "And considering that we have operated to the U.S. since 2004, we fail to understand how we can possibly be competing unfairly in 2015."

Opponents in the U.S. are adamant that Emirates has received at least $5 billion in subsidies since 2004. The group believes that the government has assumed up to $4 billion in fuel-hedging losses from Emirates via state holding Investment Corp. of Dubai (IDC), including a $1.6 billion letter of credit. The U.S. carriers also claim that Emirates has benefited from $2.3 billion of subsidized airport infrastructure.

But Emirates vehemently disagrees. As to the fuel-hedging charges, the airline states: "All cash losses incurred by Emirates as a result of its fuel trades in place in 2008-09 were settled in full from the airline's own cash reserves and not paid for by the government of Dubai. The letters of credit mentioned in the white paper were in fact provided by Emirates to our owners, [the IDC], in support of the fuel trades novated [substitution of a new contract for an old one], not the other way round." Emirates had transferred its fuel-hedging contracts to IDC.

The carrier also denies that the airport charges are a subsidy because "all airlines who use the infrastructure at Dubai International benefit." It adds that "Emirates pays the full published rates at [the airport], which are highly competitive, commercially based and in fact higher than a number of other comparable major airports."

Instead, Emirates hits back at U.S. airlines: "The real issue at hand is that the three biggest U.S. carriers . . . want

The growing Emirates A380 fleet, here at the airline's Dubai hub, is perceived as a huge threat by competitors in the U.S. and Europe.

DUBAI AIRPORTS

to further limit the international air transport choices available to American consumers, airports, local and regional economies." But "U.S. consumers must wonder why they deserve less competition . . . when Delta, American and United are among the most profitable airlines in the world, but nowhere close to being ranked among the best airlines for service or product."

The airline also points out that "there are very few network similarities between Emirates and the big three U.S. carriers, and many of Emirates' routes are to developing markets which are not currently served by American carriers."

Etihad's Callaghan shares that stance, insisting that the Abu Dhabi-based carrier is "not subsidized." Instead, its only shareholder, Abu Dhabi, gives it financial support. "One man's subsidy is another's equity," he noted at the CAPA event. He reiterated that the U.S. carriers have not been able to demonstrate that the entry of the three Gulf airlines has harmed their business.

This obscures the issue, Delta's Hirst says. The main thrust is that the three Gulf airlines are "arms of the state." "The [UAE and Qatar governments'] policy is to flow traffic over the hub to points beyond to stimulate trade and tourism," he says. "This is a legitimate economic policy but when airlines are subsidized, it distorts the marketplace."

"We are not opposed to government ownership," Ris says. "But we are opposed when those airlines have unfettered access to the U.S." He adds, "The government is the source of the competitive advantage," and U.S. airlines cannot compete with the deep pockets of the UAE and Qatar governments.

However, Callaghan points out the united front presented by the three U.S. airlines. He says the white paper the

QUID PRO QUO

Cathy Buyck Brussels

Qatar Airways appears to have secured additional traffic rights into France as part of a €6.3 billion ($7.03 billion) deal between Paris and Doha for the sale of 24 Rafale fighter jets and an option for 12 more. The agreement, if confirmed, will exacerbate the already heated debate about the expansion of the Gulf airlines' reach in Europe, and is likely to set a precedent. The United Arab Emirates (UAE), for instance, is also shopping for new fighter jets. One of its major carriers, Emirates, operates from Dubai International to Paris-Charles de Gaulle (CDG), Nice-Cote d'Azur International and Lyon—Saint-Exupery Airport, but the other, Etihad Airways, does not fly to France's regional airports.

The Qatari national airline operates three daily services to CDG with Airbus A340s and A380s and now appears to have obtained traffic rights to fly three times a week to Nice and to Lyon, France's third- and fourth-largest airports in terms of passenger count. Qatar Airways used to fly to Nice-Cote d'Azur, but abandoned the route in 2013 to focus its operations on Paris after it was unable to increase the number of weekly frequencies under the bilateral air services agreement between France and Qatar.

French President Francois Hollande did not outright deny that Qatar received new traffic rights, but emphasized that any arrangement with the airline was separate from the Rafale contract. And, he said, "It is legitimate that there are discussions and negotiations so that a certain number of air routes could be opened on behalf of a nation that also will bring a lot of tourists. And no one can doubt the cities of Nice and Lyon are particularly in favor of this."

Both airports indeed have been lobbying for this outcome for years, and the French government has been weighing for a long time whether to allow more Gulf carriers to operate to its regional airports.

The airline's main pilot union, SNPL Air France ALPA, condemned the deal. "Withholding additional traffic rights to European airports for airlines that do not respect rules on competition is the only thing that still can protect European airlines against absolutely distorted competition," the union stated.

Points Served Directly: Emirates vs. Big Three U.S. Airlines

	Emirates	DELTA	UNITED	American Airlines
Middle East	15	2	4	0
Africa	23	4	1	0
Asia	35	13	13	5

Source: Emirates

U.S. carriers circulated among government agencies, the press and lawmakers earlier this year has now been taken as "gospel" by the French and German transport ministries to freeze capacity. "This is a coordinated effort," he says.

The French and German ministers laid out a specific plan to the European Commission, but it does not seem to be workable. They are proposing that no additional traffic rights be given to Gulf carriers by any European country until a comprehensive air transport agreement among the European Union and its member states and the six countries organized in the Gulf Cooperation Council (GCC) has been negotiated, write Alain Vidalies and Alexander Dobrindt, French and German secretaries of state for transport, respectively. That agreement "should effectively guarantee the conditions of fair competition," the ministers state, and "require the financial transparency of the various entities involved in air transport; it should also include detailed provisions on subsidies, unfair practices and competition, and provide the Commission and member states with efficient means of action, going beyond the usual dispute-settlement mechanism in case of noncompliance with these provisions."

The transport ministers propose that the opening of the European market should be "limited and gradual." They argue that only third- and fourth-freedom rights, which allow basic international service between two countries, should be covered by the air transport agreement. And the competitive environment "should also be taken into account." However, Gulf carrier business models are based on sixth-freedom rights—allowing them to connect traffic via their hubs in Doha, Dubai and Abu Dhabi. Thus, any deal not containing sixth-freedom provisions would not even be considered by the GCC or the individual states.

The situation in Europe differs from the U.S. in that most countries do not have open-skies agreements in place with the UAE or Qatar but impose some limits in terms of frequencies or entry points. Germany, for example, allows Qatar no more than 35 weekly frequencies. UAE carriers can fly unlimited frequencies and seats, but only to four points. And in the U.K., where there is an open-skies agreement, the major carriers are relatively well protected in other ways: Neither British Airways nor Virgin Atlantic have extensive Asian networks, and the lack of slots at London Heathrow Airport makes it hard for the Gulf carriers to grow further in that most lucrative market, in spite of open skies.

Raidrs Raided

USAF abandons key defensive counterspace project, with no public plans to continue the mission

Amy Butler Washington and Colorado Springs

The U.S. Air Force is terminating one of its flagship defensive counterspace programs—one designed to identify sources of satellite communications interference—due to "cost and performance" issues.

Ending the Rapid Attack Identification Detection Reporting System (Raidrs) comes as Air Force officials have taken their most public and vocal stand in years in favor of improved space control projects, including a $5 billion addition to the fiscal 2016-20 budget request and an uncharacteristically open interview by Air Force Space Command chief Gen. John Hyten on the U.S. television program *60 Minutes* in April.

Raidrs, a collection of ground-based monitoring antennas, was one of three acknowledged defensive counterspace projects created more than a decade ago. It was designed to ensure that military operators—especially those supporting war operations in Iraq and Afghanistan—had nonstop service from military and commercial satellites providing crucial communications. At the time, roughly 80% of the satellite communications for forces there was provided by commercial systems. As demand for using satcom has grown so have instances of interference—friendly and hostile.

What began as a 120-day Raidrs pilot project in the Middle East in 2005 has continued to operate, though the Air Force plans to end it in September.

And just as soon as it was fielded, the Air Force pulled the plug.

Though military satellite systems have inherent encryption and/or protection, commercial systems are more susceptible to electromagnetic interference (EMI). In some cases, interference is simple: An adversary can easily overwhelm energy in a particular portion of the spectrum to deny access for users. Or an allied user can accidently emit on the wrong frequency or with too much power.

Terminating Raidrs does not necessarily suggest an end to the program's capabilities, however, as industry sources suggest military and commercial providers have learned how better to detect friendly and hostile interference with satellite communications. Military officials have been coy about just what programs could move forward to meet this requirement, suggesting there could be much work being finished in secret.

"The Raidrs mission will be accomplished through the remaining defensive counterspace family of systems," says an Air Force Space Command spokesman, Tech. Sgt. Michael Slater. He adds a list of these capabilities, including the Standard Process for Interface Recognition and Interference Targeting, Raidrs Deployable Ground System Block 0, "Bounty Hunter and Blackjack." Command officials declined to explain these systems despite repeated requests. Slater says the Air Force spent about $214 million on Raidrs; it is unclear whether this includes the cost of establishing protected sites globally for its antennas.

Events, however, overtook Raidrs technology. Slow progress in procuring the system and developing tactics since its prototype fielding in 2005 was outpaced by work in the commercial world, says one space control expert. Commercial satcom providers such as SES and Intelsat are typically required to be able to pinpoint where EMI is located to fulfill their customer contracts. They have made advances in locating EMI, though they are not necessarily equipped to address it if found in a foreign country.

The final vestiges of Raidrs will be shuttered in September; it has been a long time coming. The then-Air Force Space Command chief, Gen. William Shelton, proposed the termination May 13, 2014; the program executive officer signed the order a month later. Slater says the termination was a result, at least in part, of performance issues. The Raidrs Block 10 system fell short in operational testing and relied upon an unsupported operating system, he said. "The cost to upgrade to a newer operating system and to implement technical solutions to meet performance criteria was more than [Space Command] budgets would allow," Slater explained.

Shelton's recommendation came only two years after the objective system was fielded. Maj. Gen. Roger Teague, now director of space procurements for the Air Force secretary, said in April 2012 when he was a one-star general overseeing strategy for Space Command, that fielding Raidrs was one of the command's successes for 2012. Last month, Teague said he was unable to address what capabilities would be lost with the Raidrs termination or those that could endure, indicating security constraints.

Raidrs began in 2005 with a development contract for the system; Integral Systems of Lanham, Maryland, won the work. The company is now owned by Kratos Defense and Security Solutions. What began in July 2005 as a prototype slated for 120 days of operations in the Middle East has been used there ever since. The prototype was capable of monitoring roughly 500 signals at once. Air Force officials have provided few details on the program over the past decade.

However, during an interview with Aviation Week in 2007, the commander of the 16th Space Control Sqdn., which operated Raidrs, provided a peek into its capabilities (*AW&ST* Nov. 19, 2007, p. 52). Each Raidrs site was envisioned to consist of six, 2.4 meter (7.87-ft.) antennas to monitor signals. Another

3.7-meter dish was used to characterize interference using a powerful system called "Blackbird" that acts like a spectrum analyzer. And two more 4.5-meter antennas are used to identify a footprint of space where the jammer is located.

The operational concept called for identifying the location of the interference and then relying on military forces or diplomatic measures to address hostile jamming activity. Raidrs was designed to alert operators to anomalies in signals in the C, K_u, X and UHF frequencies; the program was envisioned before the explosion of interest in K_a communications.

The recommendation to terminate Raidrs came just over a year after officials broke ground at a $14.3 million central operating location at Peterson AFB, Colorado. Five transportable ground segments were planned for Lualualei Naval Station, Hawaii; Cape Canaveral AFS, Florida; Misawa AB, Japan; Kapaun AB, Germany; and a classified location in Central Command. This footprint was designed to provide near-global coverage in key areas such as the Middle East, North America and Pacific.

Other Raidrs blocks were envisioned. One, outlined in 2011 by Michael Hamel, then the three-star commander of the U.S. Air Force Space and Missile Systems Center, was to help counter antisatellite missiles and other threats such as lasers. This concept gained steam after China's 2007 demonstration of a developmental antisatellite interceptor to down its own aging weather satellite, a gutsy display of a capability tested by the U.S. 22 years earlier. Pentagon officials were prompted to place more priority on some space control efforts. Industry sources suggest this Raidrs block, which was never realized, likely will be satisfied by another program, which is probably classified.

With this block, satellite operators were pursuing a concept of "every satellite a sensor," says one industry source. The command could more closely monitor each satellite's telemetry to craft a baseline. Once crafted, software could alert operators to any anomaly. For example, if an imaging satellite experiences an unexpected temperature change routinely in its orbital path, this could indicate attack by a laser employed in that location, a capability long under development in Russia and, possibly, China.

"Ultimately, in the event of attempted jamming against our assets, we will leverage the full range of cross-domain capabilities to fight through that threat," says Capt. Nicholas Mercurio, spokesman for 14th Air Force. It includes the Joint Space Operations Center (Jspoc), where operators took action based on Raidrs data. His comments echo those of Hyten during recent public appearances, though the rhetoric is backed by few specifics. 14th Air Force officials declined to say what capability was lost with the termination of Raidrs and what other capabilities may be developed or fielded to continue the mission.

Mercurio points to a new Commercial Integration Cell (CIC) in the Jspoc as a measure to ensure the military is "working better to mitigate EMI" with commercial operators. The CIC will begin a six-month trial operation in July (*AW&ST* May 4, p. 63). Manned by commercial operators, the CIC will allow them to better share data on satellite health and operators in real time, a capability that is currently lacking. "The pilot program will research and develop the technical and legal aspects of public and private partnerships leveraging mutual capabilities and information sets to enhance" the mission, Slater says.

One question to be addressed: To what extent should the Pentagon protect those commercial assets on which it relies for operations.

SAAB

64,000 Shades Of Grey

Infrared sensor can detect stealthy targets

Bill Sweetman Nerviano, Italy and Linkoping, Sweden

After a year of flight tests on the Saab Gripen Demo prototype, the Selex-ES Skyward-G infrared search-and-track (IRST) sensor for the JAS 39E/F fighter is working "better than expected" and outperforming the company's simulation models, according to Saab test pilots. Meanwhile, Selex is close to announcing an agreement with a major U.S. defense contractor that would position its IRST technology as an option for U.S. aircraft.

Selex engineers now say that, after many years of investment, its IRST technology is not only a counter-jamming tool but an effective sensor in its own right, having demonstrated its ability to detect aircraft at long range regardless of any radar cross-section (RCS) reduction technology they may use. By providing precise azimuth and elevation cues to a fighter's radar, IRST also greatly increases the radar's performance against low-RCS targets.

Selex's IRST work dates back to 1988, when the company (then known as Galileo Avionica) led the Eurofirst consortium, which was chosen in 1992 to produce the Pirate IRST for the Eurofighter Typhoon. IRST work remains centered on Nerviano, near Milan, with the support of specialized centers for optics, in Florence, and infrared detectors (formerly Philips, then GEC-Marconi and BAE Systems) in Southampton, England. Pirate has been followed by a series of land- and sea-based IRSTs. Skyward-G is similar in principle and performance to Pirate, but is repackaged (in two line-replaceable units rather than one) and uses air rather than liquid cooling. Previously undisclosed details of the Pirate and Skyward-G were discussed in a late-April briefing in Nerviano.

The IRST is different from a thermal imager, engineers say, because of its long focal length and rapid mechanical scan. At its maximum magnification, used for long-range target detection, the IRST is a thermal telescope coupled to a fast, agile scanning mirror. Its output is in the form of targets rather than an image. (By "zooming out" its optics, it can act as an imager, but that is not the design-driving mode.)

In Pirate and Skyward-G, the optical system is installed vertically with the lightweight, stiff and precisely balanced azimuth-elevation scanning mirror on top, covered by a dome. The dome rotates to keep the copper-toned, IR-transparent "window" covered when the system is not in use, and contains radar-absorbent elements. The optics are complex and challenging, including reflecting, refracting and diffracting elements and coatings that can withstand heat, cold and vibration. At the lower end of the optical system is a 45-deg. mirror that directs the signal to the infrared detector.

Selex uses mercury-cadmium-telluride (MCT) linear detectors operating in the mid-wave IR (3-5 μm) band, cooled to 70K (-203C) by a mechanical pump and dewar system. A basic design choice, engineers say, is the selection of an operating frequency within either of the "windows" (3-5 μm or 8-12 μm) where IR energy passes through the atmosphere. A wider operating band will gather more energy but less detail.

The detectors use a 16-bit pixel size, which corresponds to "64,000 shades of grey" in the selected IR band, according to engineers. The result is that the system can detect very small delta-Ts (thermal differences between the target and the background), but this high sensitivity is a two-edged sword: It detects small targets but also receives a great deal of noise and clutter while generating a large stream of data—"thousands of possible targets every second," according to one Selex engineer.

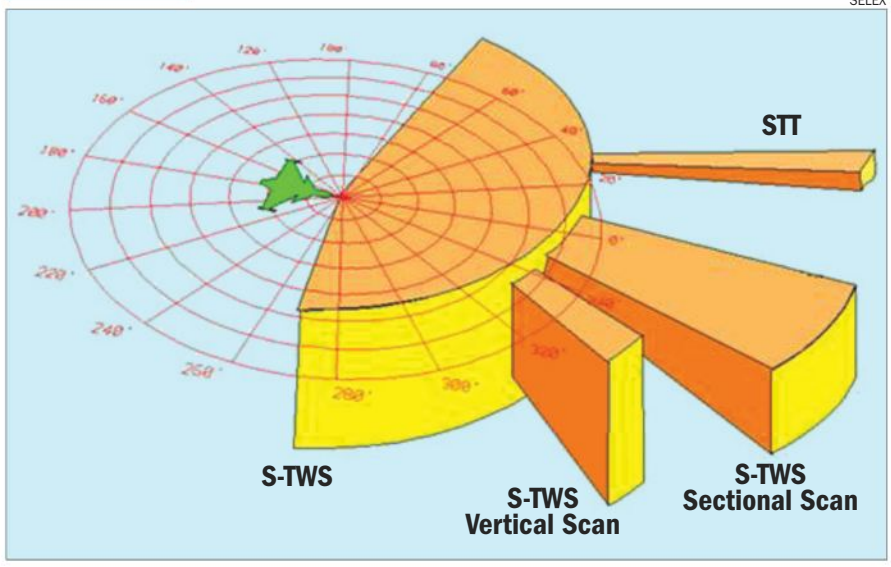
SELEX

Skyward-G infrared search-and-track system (inset) is being evaluated in the Gripen Demo prototype to support sensor fusion development.

In the past, IRSTs were bedeviled by high false-alarm rates (FAR) because the thermal picture was so complex. The solution was to set a high threshold for detecting targets, but this reduced effective range. According to Selex, "the key factor in IRST, the glue that allows you to put a system together, is the capability to develop fast and efficient processing." The company says that the work done under Pirate and other programs, including many hours of airborne test against real targets, has made it possible to combine low FARs with long range even against low-delta-T targets such as slow-moving aircraft without afterburners in use.

One key to efficient processing is the use of neural networks, a technology that started to mature as the Pirate

SELEX



Like a radar, IRST supports multiple simultaneous operating modes.

project started and that Selex first explored in the development of speech-recognition technology. A neural net is a programmable network of many simple real-time control systems, arranged in a similar way to the interconnected neurons in the human brain. Each node assigns a "weight" value to the inputs from the other nodes; by changing the weights, the neural net can change the way it responds. It is also programmed with a pattern of what the end result should be—in this case, what an IRST target track should look like.

The neural net can also "learn," in the same way that voice-recognition or spell-checking software adapts to a user's voice or vocabulary. "You can train it with data," says an engineer. "That is a target, this one is not."

Skyward-G and Pirate both have a wide field of view—80-plus deg. either side of boresight—and can perform simultaneous search and track, including single-target tracking of high-priority objectives and "split target" tracking—maintaining track on two closely separated targets. An important advantage of IRST is that it has better angular resolution than a fighter radar and can discriminate between targets that may merge together on radar.

Sensor fusion, particularly between the radar and IRST, is important to Selex's customers, the company says. Unlike radar, IRST does not inherently provide range data, except by triangulating between two or more platforms or by kinetic ranging, where the aircraft performs a weaving maneuver and the range is determined by the change in azimuth angle to the target.

However, if IRST detects a target first, it can cue the radar precisely, putting a large amount of energy on target, increasing the probability of detection and track. A fused weapon system can also use the IRST to maintain tracks with periodic updates by radar, reducing tell-tale radio-frequency emissions.

Data on IRST range is closely held. Detection range is highly dependent on the target's infrared radiation—which is in turn dependent on its airspeed—and on atmospheric conditions, and there is no single RCS-type standard that defines a target's signature. However, it has been stated that IRST detection ranges are compatible with medium-range air-to-air missile envelopes, and that in the absence of cloud, IRST will detect low-RCS targets before radar will do so. Overall, ranges in the upper tens of miles appear to be feasible against fighter-size targets.

Selex executives say IR-camouflage techniques such as paints and coatings are not effective against advanced IRST because of its high sensitivity. Compared with radar, IRST is light, compact and reasonably priced. Skyward-G weighs 40 kg (88 lb.), consumes 380 watts of power at high scan rates, and costs about as much as a small radar.

Another airborne application of IRST is Selex's contribution to the Smart Integrated Weapon Bay (SIWB) for the Neuron unmanned combat air vehicle project. This is the most advanced air-to-ground IRST produced by Selex, and is designed to detect and identify specific targets—such as mobile missile systems—against high levels of surface clutter.

PLAYING CATCH-UP

Selex's proposed tie-up with a U.S. partner is a challenge to Lockheed Martin, until now the only known IRST producer in the U.S. No all-new IRST has been produced in the U.S. since the early 1990s, when the decision was taken to omit IRST from the Advanced Tactical Fighter, which became the F-22 Raptor.

Lockheed Martin's IRST21 technology is adapted directly from the AAS-42, developed in the 1980s for the Grumman F-14D Super Tomcat, with a new processor. In different versions, it is used on F-15s for Singapore, Saudi Arabia and South Korea (built into the pylon that carries the targeting pod) and in a chin pod for Aggressor F-16s. The system is almost twice as heavy as Skyward-G, according to company data.

So far, the largest IRST program in the U.S. involves the U.S. Navy's Boeing F/A-18E/F Super Hornets, where the IRST system is installed in a modified centerline tank. The Block I system underwent a Phase 2 operational assessment in May-July 2014 and is expected to achieve initial operational capability in 2018. However, the fiscal 2014 report of the director of operational test and engineering indicated that its tracking performance had not met expectations, resulting in difficulty fusing its output with the radar.

The Navy plans to acquire 60 Block I systems followed by 110 Block IIs, with a new infrared front end. The Block II is expected to start development after the Block I system enters full-rate production, and the older systems are due to be retrofitted to the new standard.

In January, Lockheed Martin unveiled its Legion IRST pod, designed to be compatible with targeting pod stations and with provision for a data link. A near-term target is the Air Force's F-15C force. After canceling an IRST program for the F-15 in early 2011, the service has reinstated the project in the fiscal 2016 budget, with funding of $281 million.

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AVIATION WEEK

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The Raytheon AGM-65 Maverick air-to-surface missile has been test fired from the P-1.

JAPANESE MINISTRY OF DEFENSE

Mighty Missileer

Japan suspects that by the 2030s the fighter will not be the only means of air control

Bradley Perrett Beijing

Almost 60 years ago, the U.S. Navy looked at replacing fleet-defense fighters with low-performance aircraft firing high-performance missiles. The program was canceled in 1960, replaced with development of aircraft that could do more than loiter and lob missiles at distant air targets. But now Japan, challenged with a numerically superior Chinese fighter force, is taking another look at the idea.

The Japanese defense ministry chose Kawasaki Heavy Industries (KHI) on Jan. 22 to outline a program that by the mid 2030s would field an aircraft, at least as big as that manufacturer's P-1 maritime patroller, that would carry enormous air-to-air missiles with a range of at least 100 km (62 mi.), probably much more.

KHI was due on March 20 to submit its findings on the concept, which is sometimes referred to as a "missileer." The findings have not been disclosed.

The choice of KHI to study development of a missileer may simply reflect the company's experience in developing large military aircraft. Quite likely, however, the ministry and KHI have an adaptation of the P-1 in mind—or, rather, a second adaptation, since the ministry has been considering development of an airborne-early warning version and control (AEW&C) variant of the type. Indeed, an AEW&C P-1, with a powerful radar capable of collecting and transmitting fire-control data, could become the missileer. An adapted airliner could also be a candidate.

Japanese interest in such an aircraft is one more step in a direction signaled last year with publication of the latest concept design for the country's next indigenous fighter, the F-3. The design, called 25DMU, sacrificed flight performance in favor of endurance and weapon load (*AW&ST* Nov. 24, 2014, p. 22). It was, however, still a fighter, not a missile carrier that could only maneuver like a transport.

KHI's study will probably be superficial, since the ministry gave the company only eight weeks and a mere ¥900,000 ($7,500) to produce it. More significant is the specification for the research, which reveals that the ministry itself has been seriously pondering the idea. Even if the concept is eventually put aside, it is clear that Japanese military technologists suspect that sensor, fire-control and missile technologies are developing far enough to offer a radical alternative or supplement to the fighter as an instrument of air control in the 2030s.

The ministry says the contemplated aircraft must carry air-to-air missiles 4.7-8.4 meters (15.4-27.6 ft.) long and 650-1,340 kg (1,430-2,950 lb.) in weight—weapons as big as naval area-defense missiles. Dimensions and masses of 24 conceptual weapons were prepared for KHI to work with. Twelve of the missile concepts are designed for a launch velocity of only Mach 0.5, which might be expected from a loitering transport. The designs of the other 12 assume no initial velocity, meaning the missileer would launch them with the target abeam.

Since the ministry does not want an aircraft smaller than the 80-metric-ton P-1, it must have thought about and rejected such cheaper but less capable possibilities as an adapted business jet of, say, 50 tons gross weight. Or maybe it is simply sure that it would want a Japanese base aircraft, for which only the P-1 or, less probably, the KHI C-2 airlifter could be candidates.

The gross weight of the in-development Mitsubishi Aircraft MRJ regional jet will be 43 tons; the Boeing P-8 Poseidon maritime aircraft, based on the

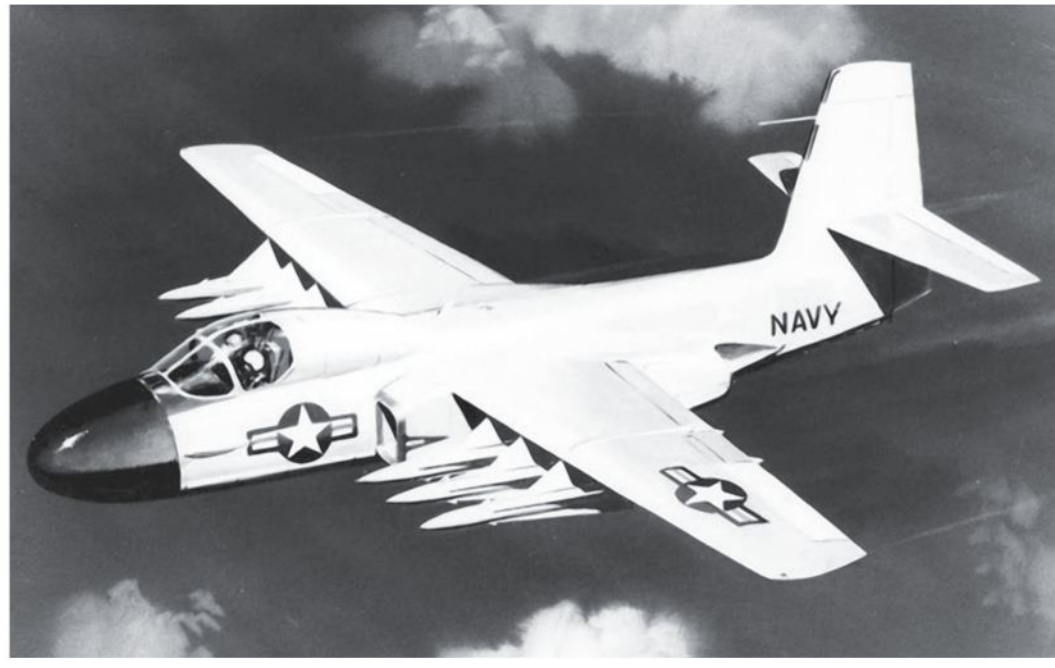
737-800, has a gross weight of 86 tons.

In its report, KHI was required to supply a specification for the possible aircraft, its performance, any record that the type may already have in service—as an airliner, presumably—and an optimum schema for carrying and launching large air-to-air missiles. The ministry also asked for a description of how the program would be executed, including what new technologies would be needed, the challenges involved, a development schedule and a cost estimate.

The required minimum missile range is surely understated. No aircraft with the flight performance of a transport would want to fly as close as 100 km from a fighter such as the Sukhoi Su-35, which China is expected to order (*AW&ST* Oct. 27, 2014, p. 18). More generally, Japan faces the near certainty

The Douglas F6D, canceled in 1960, would have used a powerful radar and big missiles to engage air threats.

its force of modern fighters will be outnumbered by China's in the decades ahead, which helps explain the interest in a concept that offers engagement from a safe range.



DOUGLAS AIRCRAFT CONCEPT

The ministry told KHI to propose an aircraft that would be "realizable" within 20 years, which implies it should be in service by 2035. KHI was further asked to describe "an outlook for the next 20 years" and to study developments in Britain, China, France, Germany, Russia and the U.S.

A review of past proposals may also have been helpful. In 1957 the U.S. Navy envisaged putting the performance in the missile instead of the aircraft; its program evolved into the carrier-based Douglas F6D Missileer, an aircraft as big as a large fighter that would have carried six 4.9-meter, 580-kg Eagle air-to-air missiles. It was canceled in 1960 but the technology and mission, fleet air defense, eventually passed to the Grumman F-14 Tomcat, which was more flexible.

Closer to the Japanese concept, Lockheed's CL-520 would have been an adaptation of the P-3 Orion maritime patroller carrying Eagles and fitted with an AEW radar and dorsal radome; it also would have been tasked with defending warships.

From time to time there have also been proposals for bombers to carry large air-to-air missiles, although the idea is not quite the same as a missileer that lacks combat-worthy flight performance but can carry very large radar antennas. In 2011 the U.S. think tank Rand proposed equipping a supersonic bomber, such as the B-1, with at least 20 air-to-air missiles, possibly derivatives of the Patriot or SM-2, with ranges of perhaps 370 km.

An AEW radar is being considered for the P-1. Japanese media report that such a version of the aircraft should be developed by the mid 2020s. In 2013 the ministry's Technical Research & Development Institute issued a requirement for one, and the aerodynamics are under study. The radar of the AEW&C P-1 would have three or four antenna faces, says a former commander of the air force's air development and test wing.

A missileer with powerful, all-around radar coverage, in contrast to a fighter with only a nose-mounted antenna, could maneuver freely except when pointing toward enemy aircraft to help its missiles on their way, if such help were necessary. Depending on missile range, flying away from a target while attacking it could be especially important for a transport-like aircraft in action with large, high-performance fighters.

Alternatively, a missileer could do without its own long-range radar by firing with data from friendly aircraft, ships and ground radars—the tactical pictures of which would have to be integrated and passed along robust data links. The ministry's specification made no mention of sensors or fire control.

An official drawing of the P-1 suggests that its weapon bay, forward of the wing, is 4.4 meters long, which is shorter than the shortest missile that the ministry told KHI to consider, 4.7 meters. An even shorter space behind the wing holds sonobuoys. So a fuselage stretch would be needed for internal carriage of any of the missiles that are contemplated. KHI must have also looked at hanging the air-to-air missiles under the wing, which is already designed to carry suspended loads, though probably nothing like the missile battery that the ministry seems to have in mind.

The Raytheon AGM-65 Maverick air-to-surface missile has been launched from a pylon on the P-1. The biggest air-to-air missile in the ministry's specification would be more than three times longer and four times heavier.

Balancing Act

Commercial Falcon 9 faces crowded launch schedule

Amy Svitak Paris

SPACEX

SpaceX's commercial satellite launches may have to take a backseat to NASA campaigns as the company balances its busy Falcon 9 manifest with sudden demand for its resupply services to the International Space Station (ISS) and a small backlog of delayed government missions.

Already the company has more than once had to push back the launch of the TurkmenAlem52E/MonacoSAT telecommunications satellite for the government of Turkmenistan. The mission was lifted to orbit April 27 on a Falcon 9 rocket after being delayed almost four months, including a March schedule slip that may have been due in part to increased demand for SpaceX to resupply the six-person ISS after NASA's other space station cargo vendor—Orbital ATK—was sidelined by a launch failure in 2014.

That mishap has left the SpaceX Dragon cargo vessel and Russia's Progress vehicle largely responsible for delivering food, water and cargo—and in the case of Progress, propellant and orbital reboosts—to the ISS.

So far this year SpaceX has conducted two ISS resupply runs. SpaceX is now responsible for three more cargo missions by December, including a delivery slated for June.

William Gerstenmaier, head of NASA's Human Exploration and Operations Directorate, says the loss of Orbital ATK's Cygnus cargo vessel atop an Antares launcher last October cost the ISS only a couple of months' worth of food. But he says the failure has highlighted vulnerabilities in the agency's commercial cargo resupply strategy. "It puts a lot of criticality on SpaceX," Gerstenmaier said in January, adding that the SpaceX Dragon and Orbital ATK Cygnus vehicles were both designed with cost rather than redundancy in mind.

For example, NASA had not originally planned to carry water on Dragon missions, leaving that task to Cygnus alone. "We've already changed the requirement to carry water on a SpaceX flight," he says. "We accepted some non-redundancy items to keep costs down, but now we need to think about that." NASA is also grappling with myriad equipment anomalies on the station, notably affecting environmental control and life-support systems. The agency recently leaned on SpaceX to carry a number of spares and other supplies aimed at troubleshooting these problems on its most recent cargo run April 14.

In addition to upcoming ISS missions, SpaceX plans to launch the Jason-3 Earth-observation mission for NASA in July, in partnership with the National Oceanic and Atmospheric Administration.

SpaceX will also complete delayed flight-test milestones under a Space Act Agreement with NASA as it seeks to develop a commercial-crew variant of the Dragon vessel expected to fly in 2017. NASA recently extended the Space Act Agreement until December, affording the company more time to complete a pad-abort demonstration that slipped from March to May. A second test—an inflight abort with Dragon atop the Falcon 9 booster—is now slated for September.

After two ISS resupply failures in the last year, SpaceX's Falcon 9 is in demand.

SpaceX also has as many as seven missions pending for commercial customers this year.

Orbital ATK's Cygnus cargo capsule is expected to pick up some of the resupply slack when it returns to service in November. Until then, the Dragon vessel could see even greater demand to conduct ISS cargo runs.

Recently, Russia's Progress 59 freighter encountered problems suspected to be linked to its primary flight computer following a successful April 28 launch from the Baikonur Cosmodrome in Kazakhstan and failed to deliver a 6,100-lb. load of cargo to the ISS. It is unclear whether the vehicle's propulsion system for rendezvous maneuvers pressurized properly.

The freighter's cargo load included nearly a ton of propellant used to adjust the altitude of the ISS and, when necessary, carry out maneuvers to avoid collision with orbital debris. The mission was also transporting food, compressed air and water containers, spare parts and research equipment.

Russia's next Progress cargo launch—the latest in a long succession of normally reliable resupply missions—is planned for early August. Around that same time, the ISS will receive a cargo delivery from Japan's HTV.

In the meantime, says NASA spokeswoman Stephanie Schierholz, the ISS orbit can be raised using the Progress vehicle now docked to the station, and there are thrusters on Russia's Zvezda module that can even be used for this purpose. In addition, she says, "We have a year's supply of fuel."

Schierholz says the SpaceX resupply mission launched April 14 carried 1,000 lb. of food and supplies, and the Progress 59 had carried 3,128 lb. of spare parts, experiments and food. "Both the Russian and U.S. segments are adequately supplied well beyond the next resupply flight, which is SpaceX," Schierholz says, referring to the June Dragon mission.

Shortly before SpaceX's April 14 cargo run, NASA said the U.S. crew aboard the station had enough food to last in reserve until Aug. 21. However, absent a subsequent resupply, the ISS crew as a whole would start using their combined reserve food supply July 5, said Robyn Gatens, NASA's acting deputy ISS program manager on April 8. Factoring in the food and provisions Dragon carried to orbit last month, she said, would buy the crew only until July 24. "We're eating into margins . . . but we're not too bad off there," she said.

—With Mark Carreau in Houston

Safety First

With a focus on compliance, not exemption from airworthiness requirements, company takes FAA certification route for small UAS

Graham Warwick Washington

FAA appeals for unmanned-aircraft manufacturers to step up to the challenge of type certification and pave the way for others—rather than seek exemptions from airworthiness regulations to enable commercial operations—have been answered by at least one company.

Aero Kinetics—a Texas-based company that flies special-mission aircraft, helps businesses select aircraft and maintains them, and provides engineering and certification services—has applied for the first type certification of a multirotor small unmanned aerial system (UAS).

In March, Aero Kinetics filed for type certification of its 4-lb.-payload Little Bear, 8-lb.-payload Big Bear and 10-lb.-payload Apollo quadrotor UAS. The company followed up in April by applying for experimental certification of the Little Bear so it can begin flight-testing the small UAS.

"We are doing the thing we think is critical: establishing a process with the FAA to have them say our aircraft are safe to fly in the NAS [National Airspace System], instead of throwing away 70 years of experience in ensuring aviation is safe," says Aero Kinetics CEO Hulsey Smith.

Smith says the company wants to work in partnership with the FAA to develop a type-certification basis for small multirotor UAS, "and not force them to certificate a toy"—a reference to the consumer "drones" being approved for commercial operations under the FAA's Section 333 process.

Section 333 grants exemptions from airworthiness requirements for UAS, provided the operations are low-risk. The FAA has so far granted 246 exemptions for a wide range of missions, many of them using consumer drones such as the DJI Phantom and 3D Robotics Iris.

Section 333 limits operations to daylight, below 400 ft., within visual line of sight of the operator and well away from people not involved in the operation. Aero Kinetics' type certification will allow the company's UAS to operate anywhere in the NAS outside restricted airspace, Smith says.

The company intends to demonstrate day/night visual-flight-rules capability, as well as beyond-line-of-sight operation, to the FAA during the type certification process, he says.

Where consumer drones have developed out of the hobby market, Smith says Aero Kinetics is using aerospace-grade materials and systems, including additive-manufactured metal parts, triple-redundant flight controls and Automatic Dependent Surveillance-Broadcast (ADS-B) "In" and "Out."

The biggest challenge, Smith says, is the lack of aerospace suppliers in the UAS market, so Aero Kinetics is vertically integrated, building most of the vehicle itself while it works to develop partners. The data link is supplied "by one of the largest aerospace communications businesses in the world," he says.

The company designed a clean-sheet small UAS after being approached by a Fortune 100 client in 2012 to develop a system that could operate in the NAS with a non-certified pilot, Smith says, adding that Aero Kinetics already has systems flying in the U.S. with operators that have their own certification basis.

Beginning with the Little Bear, its least complex design, Aero Kinetics plans certification flight-testing at FAA-designated UAS test sites in Texas, North Dakota and New Mexico, as well as a private test site the company is working with the FAA to authorize.

"We have made provisions for a significant testing program, to gain many, many hours of experience at both the UAS and private test sites," Smith says. Certification is expected late in 2015 or early in 2016. "The program is heavy on testing and demonstration. It's all 'show me,'" he says.

Little Bear has four shrouded rotors and measures 34 X 34 in. The battery-powered UAS can fly for 35 min. carrying an electro-optical/infrared sensor. Big Bear has ducted propulsors providing a greater than 40% increase in efficiency for higher performance, including a 45-min. flight time.

Little and Big Bear are designed to fly over people, for missions such as news gathering. Apollo is a "heavy-lift" small UAS designed to carry heavier and more advanced sensors but not fly over or near people, instead being intended for operation over more controlled locations, Smith says.

AERO KINETICS CONCEPTS

The use of aerospace-grade materials and systems is key to Aero Kinetics' certification plans.

Flying Engine

Core and fan for flying testbed A350-1000 engine will be mated at Rolls-Royce this month

Guy Norris Derby, England

Rolls-Royce is assembling the first flight-test version of the Trent XWB-97 A350-1000 engine, the highest-thrust production engine ever made by the manufacturer.

The fan case for the first flight engine, No. 26001, is nearing completion and vertical stacking of the core is progressing quickly at the manufacturer's Derby, England, facility after getting underway toward the end of April. "The engine will be moving to Toulouse around mid-year and is due to fly in the beginning of the fourth quarter," says Simon Burr, Rolls-Royce's chief operating officer for Civil Large Engines.

The 97,000-lb.-thrust engine is the first of two units destined for initial evaluation flights on the Airbus A380 flying testbed MSN001, and will be used for evaluating engine operability, relights and handling. Beyond engine-specific testing, Airbus also intends to use the XWB-97 on the A380 for integrated nacelle tests. "It will do this to take credit for A350 certification and flights will run well into 2016, so it is not a short program," says Burr. The first A350-1000 is due to fly in mid-2016 and is scheduled to enter service in 2017, two years after the Trent XWB-84-powered A350-900.

Unlike the -84, which first flew on the A380 in February 2012, the higher-thrust engine will not have undergone simulated altitude evaluation in a test cell before it takes to the air on the flying testbed. "On the -84 we did altitude work in North America (at the Arnold Engineering Development Center in Tennessee), whereas on the -97 we are using the A380 for flight-test data at altitude," says Burr. "We've already proved the basics from the -84 and we can get useful data off that," he adds.

Since making the first run of the XWB-97 in July 2014, Rolls has focused ground testing on the newer design features of the engine. These were introduced to generate 13,000 lb. of additional thrust over the baseline XWB while maintaining the same fuel-burn efficiency, 118-in. dia. fan and external nacelle packaging. The higher-flow fan

MARK WAGNER/AVIATION-IMAGES.COM

turns 6% faster than the -84 and pumps more air. The XWB-97 is also designed with a 5% larger core and higher temperature capability as well as unshrouded high-pressure turbine blades.

Burr adds that while Rolls was "very pleased with the first engine, which ran

Stalled Relations

New EASA rule highlights divergence between Europe, U.S. on full-stall training

John Croft Washington

Europe, beginning in May 2016, will require its airline pilots and commercial business jet pilots to complete a loss-of-control prevention and recovery training program every three years as a preventative for loss-of-control accidents, but without the full-stall training requirement the FAA has mandated for similar training in the U.S.

The new operational rules, announced May 4 by the European Aviation Safety Agency (EASA) and the International Air Transport Association, were fast-tracked by EASA Executive Director Patrick Ky, resulting in a "limited consultation" process, according to EASA. "A number of accidents in the recent years have demonstrated that loss-of-control remains a major area of concern for aviation safety and should be tackled with the highest priority," Ky says.

Embedded in the rules is guidance for how airlines and commercial operators can meet EASA's intent, including a schedule of ground training, flight training and simulator training that must be completed in part every year, but in full every three years. Airlines can use ground training, flight simulators or in-aircraft training for upset-recognition training, but only simulators for upset recovery.

What EASA has not included is a requirement for pilots to regularly experience full stalls in the simulator, a key element in FAA pilot training rules mandated by Congress and published in 2013, in large part due to the Continental Connection Bombardier Q400 accident in 2009. Pilots today are taught to recover from a stall at the first indication, whether by an aural or tactile indication, as simulators do not generally model the non-linear aerodynamics, and corresponding aircraft motions and control effects in and beyond the stall angle-of-attack or for large sideslip angles.

The Continental Connection accident, along with two major 2009 loss-of-control related accidents for European carriers—Air France Flight

ROLLS-ROYCE

Fan case (left) and core (below) for first flight-test XWB-97 come together in Derby, England.

for 150 hours," the company has made some design modifications to improve durability as a result of inspections following a teardown. Chief among these was an adjustment to the gas temperatures generated across the width, or traverse, of the combustor exit. "At the exit point you set up a particular profile in terms of temperature and you match the materials to that. Our first runs showed that profile was flatter than desirable, which would mean the high-pressure turbine blades and nozzle guide vanes would end up seeing a higher temperature than [designed]" explains Burr. Changes were made and tested on a combustor rig and "we have got a really nice match to the design now. Those changes are going into the next two engines on build right now and will feed into certification."

"In terms of clearing the XWB-97 for flight, the icing work is complete and the first phase of type testing has been done. We have to do the medium bird-strike test, and we will be doing that over the next few weeks," Burr says. The first flight-test engine is "very close to production standard, in fact much closer than the first -84 was. The only differences are just in terms of the external dressing and various small design changes," he adds, referring to aspects such as the configuration of the systems and wiring harnessing, which is "as close as possible to the final standard."

"When we built the first engines we used a different harness technology to experiment with it, but here we have aligned it so it will feel the same to a mechanic servicing either the -84 or the -97," says Burr. The two engines already share 80% of the same line replaceable units, but Rolls is refining the configuration to increase the "feel" of commonality. "It's about things like where things will be positioned. We've done a lot of design changes to align it to the first A350-900 in service in terms of the -84 engine," he adds.

Digital Extra *Read about part of the biggest shake-up to Rolls-Royce's production system since the start of the big-fan era.* **AviationWeek.com/TrentEngines**

447 and Turkish Airlines Flight 1951—galvanized regulators and the international community to take a deeper look at pilot training in an era where fewer and fewer pilots have a background that includes aerobatic, or all-attitude training—similar to what is provided in the military—that gives pilots experience in stall and post-stall aircraft behavior and physiological effects. The FAA says upsets are most often precipitated by a stall.

While EASA, through its Rulemaking Group, is calling for training in many of the same areas that the FAA targeted with its rule—training in stickshaker and stickpusher activation, recovery from developed upsets, nose-high and nose-low events and system malfunctions, including fly-by-wire degradations and stall protection system failures—the agency stopped short on the magnitude of the stall.

"The Rulemaking Group experts do not agree on the benefits of 'full-stall' training for flight crew," says EASA. "Moreover, some experts have indicated that currently industry is not ready for such a radical change to simulator capabilities, mainly because the necessary airplane-specific post-stall data needed is not readily available at this stage. Consequently, stall event recovery exercises in current or grandfathered FFS [Full-Flight Simulator] should be conducted as approach-to-stall exercises only."

The statement correlates with Airbus's position: In a fly-by-wire aircraft with envelope protection (as are all Airbus production aircraft), pilots should be trained to recover when wing buffeting or indicators signal an imminent, or approaching, stall, while the aircraft is in its normal operating control law, negating the need for training beyond that realm.

Boeing on the other hand, spurred by the flight training rulemaking, is already developing extended envelope models for its production aircraft and is offering the models to its customers. The FAA is evaluating "representative" stall models to gain insight for an upcoming simulator rule change (to incorporate extended envelope stall models) but also to evaluate alternatives for airlines and training centers to acquire the models for any aircraft that OEMs may not support. The agency has a contract with Bihrle Applied Research to investigate representative models for fly-by-wire, envelope-protected aircraft including the Airbus A320, A330 and A340, and for high-wing twin-turboprop commuter aircraft, similar to the Q400, and a T-tailed regional jet similar to the Bombardier CRJ200 or the Embraer ERJ 145. The models are being tested in an FAA full-flight simulator in Oklahoma City.

The representative model approach does not depend on any OEM data for the stall models, instead using wind tunnel results and computational fluid dynamics (CFD) modeling and bringing in "subject matter experts" who have stalled the transports to evaluate the simulator behavior in the stall. The models are accessed externally to the simulator using Bihrle's StallBox technology, which modifies the simulator's behavior in the extended envelope regime. To date, the company has delivered an A330 and a Boeing 737-800 representative stall model to the FAA, and plans to test the high-wing turboprop extended envelope model later this year. The models are not meant to be exact replicas of an aircraft's performance past the stall, but to deliver typical characteristics, motions and control effects that can be used for positive transfer of learning.

EASA did leave the door open for the extended models in the future, saying it will consider "proposed amendments" to the rules to include full-stall training, in part based on "the outcome of ongoing FAA activities."

Along with developing stall models, Bihrle is also building applications to keep the simulator within limits.

BHIRLE APPLIED RESEARCH

Revealing Inputs

Germanwings crash raises questions about personalized pilot data analysis

Jens Flottau Frankfurt

A preliminary report released May 6 by French air accident investigation authority BEA suggests that the March 24 crash of Germanwings flight 9525 appears to have been planned rather than a spontaneous act by First Officer Andreas Lubitz.

The document reveals that Lubitz made suspicious altitude inputs on the outbound flight from Dusseldorf to Barcelona on the same day. All evidence points to Lubitz having flown the aircraft into a mountain in southern France on purpose during the return flight after the captain had left the cockpit. All 150 on board were killed.

Because the changes in altitude settings on the first flight were made while already in a descent approved by ATC, the descent rate was unchanged and since the captain was not in the cockpit at the time, there was no other crew member who could have noticed. After the accident, Lufthansa and Germanwings, among other airlines, changed procedures and now require at least two persons in the cockpit at all times.

However, industry officials say air traffic control could have at least in principle noticed the varying altitude inputs because the aircraft was equipped with a mode S transponder. This allows air traffic controllers to manually pull up information about the altitude selected by the flight crew, but they do not routinely do so, to avoid being overwhelmed by a vast amount of data.

Lufthansa could not immediately clarify whether it has subsequently checked Lubitz's historical data from previous flights that could reveal similar behavior patterns. That data is available in principle, but is normally analyzed anonymously to identify broader trends for pilots as a group. But it is technically possible to pull data about individual pilots.

During a period of less than five min. on the first flight, Lubitz, who had a history of depression, also behaved strangely according to the report. The captain had left the cockpit as the aircraft cruised at 37,000 ft. About 30 sec. later the Bordeaux en-route control center instructed the crew to start its descent to 35,000 ft and initiate its approach to Barcelona. The aircraft was put into the correct descent. But after another 18 sec., the selected altitude was changed to 100 ft. briefly, then to 49,000 ft. and back to 35,000 ft. ATC asked for a further descent to 21,000 ft., which Lubitz set. Over the following two min. he again selected 100 ft. and several other target altitudes before "stabilizing" at 25,000 ft. Then the cockpit door buzzer is heard. Noises of the door unlocking and opening are recorded with some significant delay 14 sec. later.

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Contents

The next issue of the Defense Technology Edition will be dated July 6-July 19.

Fuel Economy

Lightweight UAV cartridge converts solid hydrogen to electric power

As ubiquitous and essential as mini-UAVs have become to military and security forces, a key aspect of performance—airborne endurance—remains problematic, since it is limited by the weight of the power source. In vehicles where electric motors are in use, designers must minimize battery and fuel-cell weight without radically affecting time aloft.

A breakthrough in this area is claimed by Horizon Energy Systems of Singapore, with a 700-watt-hr./kg (2.2-lb.) fuel cartridge for mini-UAVs—typically in the 5-12-kg range—that uses an on-demand, solid-fuel hydrogen-generation process to develop power.

The cartridge, called Aeropak-S, which debuted in North America at the Auvsi (Association for Unmanned Vehicle Systems International) show in Atlanta, May 4-7, eliminates the need for a catalytic reactor, which in turn reduces the size, weight and complexity of the component, according to Horizon Energy CEO Taras Wankewycz. The result, the company says, is a self-contained "plug-and-play fuel cartridge system" that outperforms most other "feedstock options" in "performance, safety and scalability of manufacturing."

The fuel cell uses algorithms in its software to initiate controlled chemical reactions that provide a steady source of power in flight. The unit operates without a catalyst, and purges waste during flight, further reducing weight.

The dimensions of the cartridge are 126 X 116 X 138 mm (4.9 X 4.5 X 5.4 in.). The fuel weight of the Aeropak-S cartridge varies to suit mission needs. Versions range from 0.9 kg for 1 hr. of flying to 2.3 kg for 10 or more hours. In contrast, a 200-watt-hr./kg battery weighs 10 kg for 10+ hr. of flight, while a liquid fuel cell produced by the company weighs 4 kg for similar endurance.

A company-generated graph shows that at a gravimetric capacity of 7 wt. %, Aeropak-S yields a volumetric capacity of 45 grams per liter (about 1.6 oz./0.26 gal.), more than other fuel sources including liquid and compressed hydrogen. Horizon Energy maintains that this puts the fuel system "at the performance edge" of current hydrogen storage technologies. The company states that the energy density exceeds the 2015 performance targets set by the U.S. Energy Department.

The fuel cartridge generates 200 watts of continuous power and achieves 600 watts for 2 min. Its output range is 20-32 volts, and the unit operates effectively at temperatures as low as -40F, and humidity as high as 95%.

The company, which specializes in the development of ultra-light fuel cells, tried out the Aeropak-S system on a commercial UAV earlier this year, and is developing custom versions for undisclosed aerospace OEMs that will soon be in commercial production. The company provides design guidance should a UAV modification be needed to accommodate the fuel cartridge.

Units are designed for fixed-wing and rotorcraft. A system is in the works that will allow users to extract hydrogen from local water sources such as streams and rivers for use as fuel.

—Pat Toensmeier

U.S. NAVY

Mini-UAVs can increase flight endurance with a new solid-hydrogen fuel cartridge developed by Horizon Energy Systems.

Common Core

U.S. Army seeks common fire control for weapons

The U.S. Army is increasing efforts to develop a common fire-control system for various weapons. By implementing common interfaces, software and hardware, the service anticipates considerable savings in a number of areas, notably development time, testing, procurement, training and, ultimately, deployment.

The goal was expressed by Ralph Tillinghast, director of the Collaboration and Innovation Laboratory, at the Army's Armament Research, Development and Engineering Command (Ardec) at Picatinny Arsenal, New Jersey.

Speaking at Ardec's 2015 Armament Systems Forum last month, Tillinghast noted that beneficiaries of the effort include troops, who would not need to learn new fire-control systems as weapons are developed.

In comments reported by the Army News Service, Tillinghast noted that the service has been phasing in common fire controls on some weapons since 2000. The first application was the 120-mm MFCS-H, or Mortar Fire Control System-Heavy, whose software and hardware were transferred to the dismounted version, the MFCS-D. This reportedly saved $9.6 million in software development costs and three years of development time. And because soldiers were familiar with the MFCS-H software, it took less time to train them.

Tillinghast cited six other programs that adopted common fire-control systems from the MFCS-H, such as the 120-mm Dragonfire II heavy mortar, M119 howitzer and the MFCS for the

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F-18 photo courtesy of the U.S. Navy. Taken by Photographer's Mate 2nd Class Christopher L. Jordan.

The Army's common fire controls yield savings in time and money for weapons development. The 2nd Cavalry troops are firing a 155-mm M777A howitzer.

U.S. ARMY

M1126 Stryker Combat Vehicle. Time and cost savings for these applications ranged from $5.5 million/36 months for Dragon Fire II to $5.6 million/30 months for the Stryker and $6 million/31 months for the M119 howitzer.

Work is ongoing for mortars and towed artillery, but Tillinghast wants the program expanded to include missiles and other weapons. He also wants to see commonality among all branches of the armed services. In addition to software and hardware, this would include transitioning to common networks, geodetic translation, mapping, peripheral interfaces and meteorological data.

Eventually, Tillinghast envisions common hardware solutions that allow operators to plug in different displays and sensors on their weapons.

The downside is security, which will be especially acute as all the services move toward cloud-based computing for most operations. There is a potential for cyberattacks that compromise weapons, or even technical glitches.

Nevertheless, the advantages of common fire-control systems outweigh the negatives vis-a-vis time, money and speed of implementation. And ongoing advances in software and cybersecurity could diminish the opportunity for hacking and related attacks.

—Pat Toensmeier

Wave of the Future

Dutch radar deal with Thales maximizes ROI

The Netherlands Defense Ministry announced a deal with Thales Netherlands for joint maintenance and assured component supply of six Smart-L EWC (early warning capability) radars. The partnership agreement enhances air-defense capabilities (including ballistic missile defense) and, significantly, optimizes defense spending by guaranteeing a greater return on investment.

Four of the radars are on the country's air-defense and command frigates. The navy is responsible for routine onboard maintenance, while Thales guarantees spare parts availability and maintenance training and support. The 16-year pact takes effect in 2018.

Two land-based radars are being supplied to the Royal Netherlands Air Force to replace medium-power systems that supplanted radars installed in the 1970s. The sale closed in late 2014, and also mandates a 16-year service and training partnership. No date was given for when this contract takes effect, although industry sources imply it is 2018 as well.

The Netherlands boosted 2015 military spending to €8 billion ($8.7 billion), 5.2% more than in 2014. The Hague reportedly plans to increase real defense spending by €100 million annually, after years of cutbacks. Factors driving this decision include the July 17, 2014, downing of Malaysia Airlines Flight 17 by Russian-backed rebels in Ukraine, which killed 193 Dutch citizens, and the realization that further defense cuts would imperil capabilities.

—Pat Toensmeier

THALES

The Netherlands and Thales struck a 16-year partnership deal for service and maintenance of six Smart-L EWC naval and air force radars.

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On Line And On Target

More bang for the buck is a key to program success

Bill Sweetman, Michael Fabey and Graham Warwick Washington and Francis Tusa London

Failed and problematic acquisitions hog defense headlines, but some projects either go well or recover from early issues. Here we look at five systems and the factors that made them work and, in some cases, survive determined attempts to cancel or replace them.

RAYTHEON TOMAHAWK

U.S. NAVY

Of all first-generation cruise missiles, the ship- and submarine-launched Tomahawk has been the most versatile and widely used, with more than 2,000 missiles launched. As one observer puts it, the Tomahawk contractor and customer "corrected bad mistakes faster than any other missile program," while in inflation-adjusted terms cost has come down with each variant. Raytheon claims that the current Block IV weapon is half the price of the Block III.

The Block IV Tactical Tomahawk is unique in featuring multiple navigation systems, including the original terrain profile matching system, inertial navigation, GPS and digital scene matching. Another unique attribute is that it can be retargeted in flight: An operator programs the weapon's sensors and data link to perform strike-damage assessment on its first target and move on to the second if the first has been destroyed.

Meanwhile, the U.S. Navy and Raytheon continue to refine the land-based Tomahawk Strike Network, which develops targeting plans for missiles at sea, from facilities in Hawaii and Virginia. The time to create a flight plan has come down from "days to minutes," Raytheon says.

Raytheon argues that the Tomahawk can be relevant "to 2020" with proposed upgrades. These include a radio-frequency seeker, comprising a passive system and active millimeter-wave device for tracking and identifying moving targets. Raytheon tested the passive system last year and is preparing to fly the active seeker on its T-39 test aircraft. Also on offer is a new communications system to augment UHF satellite communications equipment, and the Joint Multiple Effects Warhead System, with better capability against hard targets.

PREDATOR/REAPER/GRAY EAGLE

USAF

The iconic weapon of the U.S. counterterror campaign that began in 2001 was developed without a formal military requirement and owes its existence to a CIA program that covertly bypassed Pentagon and congressional plans.

The key to the success of the original General Atomics RQ-1 Predator was that it was, at the time, the only unmanned aerial vehicle with a reliable high-bandwidth, beyond-line-of-sight communication and control system. It was also small and inexpensive, but with long endurance, and reliable. As a complete system, it had a theater-wide, forward-deployable capability that nothing at the time matched. The post-Bosnia decision to fit the RQ-1 first with a laser designator, and then with missiles, came about because the system had proven its utility.

These features were the legacy of a difficult development starting with the U.S. Defense Advanced Research Projects Agency's Amber, produced by Leading Systems. When UAV work was consolidated under a joint program office in 1987, on the premise that prime contractors would fund most development, Amber became an orphan. Its simpler sibling, the Gnat, was taken over by General Atomics-Aeronautical Systems Inc. (GA-ASI) and sold to the CIA.

The current Predator/Reaper/Avenger family retains features of the RQ-1, which constitute the "secret sauce" behind its success. An aerodynamically efficient but simple airframe is mated to a proven engine. Flight control and vehicle management systems are proprietary, as is the software, but the architecture is open to sensor suppliers. Remote piloting is preferred to automated flight—the U.S. Army finally pushed autoland into the GA-ASI line, with Gray Eagle.

Most major developments in the program, including two new platforms (Predator B/Reaper and Predator C/Avenger), have been company-funded, which gave GA-ASI control over access to the system and kept rivals away.

RAYTHEON SENTINEL R1

CROWN COPYRIGHT

In one decade, the Royal Air Force's Raytheon Sentinel R1 airborne ground surveillance radar went from being an anachronism to a vital intelligence, surveillance and recon-

naissance asset, to heading for the scrap heap, and back to being the U.K.'s most important single system.

It started life as the Airborne Stand-Off Radar, an air-to-ground surveillance system whose design stemmed from programs begun in the late 1980s to enable the U.K. to spot and track Soviet and Warsaw Pact armored units advancing through Poland into Germany. As such, its future looked doubtful in the late 1990s as full-scale development began.

But it has proven to be a "must-have" system.

Need pattern-of-life data about part of Afghanistan, so IED teams can be tracked down? Call Sentinel. Want tracking of Libyan armor units prior to air strikes? Sentinel was about the only asset able to do this in 2011 against Col. Muammar Gaddafi's forces.

In 2011 it was also discovered that the non-optimized radar could undertake significant maritime mapping, opening up a role in maritime surveillance.

Sentinel was one of the first assets called for by France when it went into Mali in 2014. It has also been called upon for surveillance in Iraq and Syria, and for tracking Boko Haram forces in Nigeria.

The Sentinel R1 cost £950 million ($1.7 billion) in development and procurement costs for five aircraft and ground systems—a fraction of the investment in Joint Stars, which competed against the system. Operating costs are £35-40 million annually for 3,500-4,000 hr.

An airframe/avionics upgrade is needed, and sensor modifications are also in the mix, all of which will be tight considering the U.K. budget. But as a system in demand, it should be able to surmount that hurdle.

BOEING CH-47 CHINOOK

U.S. ARMY

This heavy-lift helicopter could be the U.S. Army's first 100-year-old aircraft when it finally retires, as planned, after 2060.

The CH-47's longevity is thanks to a pragmatic approach to helicopter procurement that has seen the Army remanufacture Chinooks twice: first from the CH-47A to the more-powerful D model; then from the D to the machined-airframe, digital-avionics CH-47F.

When the Army completes the fleet-wide D-to-F transition in 2019, it plans to launch another remanufacture, to the Block 2 configuration. This will restore the Chinook's lifting capacity to its A-model high, before it was eroded by weight growth in D and F.

Already the Army is taking about a Block 3 Chinook, another round of upgrades centering on reengining with the Future Affordable Turbine Engine—the same turboshaft technology intended for the Future Vertical-Lift Medium

replacements of the Sikorsky UH-60 Black Hawk and Boeing AH-64 Apache.

The Chinook's success is due to design—the tandem rotor makes it an efficient heavy-lifter—and financial reality. Since the CH-47 first flew in 1961 as the YCH-1B, the Army has never again been able to afford to develop such a large and sophisticated helicopter.

Boeing helped assure the Chinook's long run by performing reliably, and delivering the aircraft on budget. And while it continues to build Army and export CH-47Fs under a money-saving multi-year procurement contract, Boeing is developing advanced rotor blades, tactile-cuing flight controls and brownout-defeating sensors to keep the Chinook on the front line.

AEGIS COMBAT SYSTEM

U.S. NAVY

The Aegis was developed to counter the threat of a Soviet missile attack at sea against a vulnerable U.S. fleet. Aegis morphed into the gold standard for not only vessel defense against air threats but ground-based versions for ballistic missile defense (BMD) on land or sea.

As the 21st century began, the Navy was on course to phase out the DDG 51 Arleigh Burke-class guided missile destroyers and their protective Aegis shields, to make way for the DDG 1000 Zumwalt-class ships and their combat systems anchored by advanced dual-band radars. But in response to cost constraints—and increasing ballistic missile threats—the Navy opted to slash the Zumwalt buy, restart the Burke production line and bolster the new DDG 51 ships with a series of upgrades—including for Aegis—collectively called Baseline 9.

Prime contractor Lockheed Martin revamped the software and related equipment for better defense against air and ballistic threats, under the funding umbrella of the Navy and the Missile Defense Agency. Raytheon is working on a new sensor—the Air and Missile Defense Radar—which promises to make the system more formidable, while reducing cost, size, weight and power needs.

Aegis also serves with several foreign navies: Japan, Spain, Norway, South Korea and Australia.

Lockheed and partners took the shipboard system and replicated it on land for BMD in an Aegis Ashore unit. The first installation is in Deveselu, Romania, as part of a European BMD system. Radar and associated equipment are in a structure built to deckhouse specifications. There is also discussion of an anti-aircraft warfare capability.

Fast Fury

Special force trains for rapid intervention in Eastern Europe

Nicholas Fiorenza Eindhoven, Netherlands

USAF SSGT. ANDREW DAVIS

Czech paratroopers board a C295 during Exercise Noble Jump.

The NATO Response Force (NRF), created in 2003, is transitioning into a rapid-reaction force in an effort to reassure Eastern European member-states that there will be timely support after an attack.

The NATO summit in Wales last September approved creation of a "very high readiness joint task force" (VJTF) for the NRF, which—combined with the prepositioning of equipment and logistics and command and control personnel in Eastern Europe—should reduce the response time to two days.

This compares to an original response time of up to five days, led by a deployable joint task force developed for the purpose. The old NRF concept consisted of a brigade-size land component, naval task force composed of a carrier battle group, amphibious task group and surface action group, air component capable of 200 combat sorties a day, and special forces.

Whereas the NRF's initial entry force was a spearhead battalion, the VJTF is a brigade-size force of around 5,000 troops consisting of a land component of up to five battalions, supported by air, naval and special operations forces. Follow-on forces will bring the NRF's strength up to 30,000 in 7-30 days, compared to 15,000 under the previous structure, and it can be reinforced by a pool of response forces, as was the case for the previous NRF operating concept.

The VJTF has reached interim capability and is conducting exercises throughout 2015. The first of these, March 4-5, involved the 1st German-Netherlands Corps, the NRF's standby land headquarters during 2015 and therefore the interim VJTF.

The troops practiced alert procedures and rapid-deployment preparations, establishing an initial command element and communication and information systems so headquarters could command and control forces in the mission area. During the exercise, personnel and vehicles of the VJTF's operational liaison and reconnaissance team were packed and loaded onto one of three NATO strategic airlift capability C-17s by Swedish and U.S. loadmasters, but did not fly.

Exercise Noble Jump, the first part of which took place April 7-9, was the next mission, and involved 1,500 troops from 11 nations. Germany, Poland, Norway, Denmark, Hungary, Lithuania, Croatia, Portugal and Slovenia tested their headquarters' response to alert procedures. High-readiness units from the Netherlands and Czech Republic deployed equipment and troops to airports and railheads.

On April 7, the Dutch 11 Air Mobile Brigade and Czech 4th Rapid Reaction Brigade were ordered to prepare to deploy their troops and equipment within 48 hr. Participants in the exercise were given a 10-day window but did not actually know when the order to move would come, according to NATO and Dutch officers.

In the Netherlands, 200 paratroopers of the 11th Infantry Battalion of the Grenadier and Light Infantry Guard Regiment, stationed at Orange Barracks in Schaarsbergen, received orders to move on the morning of April 7. For 48 hr. they readied vehicles, equipment, weapons and rations. On the morning of April 9, they moved by road to Eindhoven AB, checking in at the terminal but not actually boarding the Royal Netherlands Air Force C-130 that took off afterward.

The drill was similar in the Czech Republic, where 150 soldiers of the 43rd Parachute Battalion moved to Chrudim AB, where they boarded a Czech air force C295. Others went to a train station, where their vehicles and equipment were loaded onto railcars.

Col. Mariusz Lewicki of the Polish army, head military planner for the VJTF at Supreme Headquarters Allied Powers Europe, said the lead troops were able to move in less than 8 hr. and the remainder in less than 48 hr.

The 900 German soldiers recalled to their units in Marienberg, Gotha, Idar-Oberstein and Bad Salzungen for the exercise took a bit longer, albeit with heavier equipment. Mechanized Infantry Battalion 371, equipped with the German army's future soldier system, Boxer armored transports and Marder armored infantry fighting vehicles, was ready to move in five days.

While no troops moved beyond their air and rail heads during the first part of Exercise Noble Jump, Part 2 on June 9-20 will involve units assigned to the VJTF deploying to the Zagan military training area in western Poland.

Exercise Trident Juncture 2015, to be held in Italy, Spain and Portugal Oct. 21-Nov. 6, is expected to train and test the wider NRF, including air, maritime and special forces, and be the final step in certification of command and control elements for 2016, when NATO wants the force to have achieved full readiness.

NETHERLANDS DEFENSE MINISTRY

Dutch parachute troops pack their kits during the VJTF readiness exercise.

Gaining Focus

Submarines and fighters are Brazil's top priorities

Bill Sweetman Rio de Janeiro

The cost and scope of two projects in Brazil—co-development and production of Saab JAS 39E/F Gripen fighters and construction of five submarines, the last of them nuclear-powered—will delay launching other major projects, such as renewal of the country's surface fleet and the SisGAAz ocean and littoral surveillance system, according to industry executives at the LAAD defense and security show here in April.

"There will not be too many big programs" in the near future, says Rogerio Salvador, future business development director for Odebrecht Defense. Odebrecht is partnered with France's DCNS on the Prosub submarine project and owns missile-maker Mectron. The company is completing construction of a submarine shipyard at Itagui and will also build a submarine base.

Four 2,000-ton submarines based on the DCNS Scorpene Class—diesel-electrics without the optional Mesma air-independent propulsion system—are due to be commissioned between 2017 and 2023, followed by a 5,000-ton nuclear boat, with the navy leading the design work. A prototype of the submarine's reactor is expected to be running by 2017.

MBDA's new Sea Ceptor anti-air-warfare missile has been selected for Brazil's Tamandare Class corvettes, but the schedule for the ships, the first element of the Prosuper warship program, is uncertain, notes Phil Gazard, naval systems executive for the European missile-maker.

Meanwhile, because of Prosuper delays, MBDA is looking at the potential for early replacement of Sea Wolf missiles on Brazil's former-Royal Navy Type 22 frigates because the weapon's continued utility is in doubt: the Royal Navy's stock of Sea Wolf rounds is reaching its age limit. The approach would be the same that the RN uses on its Type 23 ships—transferring Sea Ceptor systems to new ships (the Type 26) when they are ready.

Israel Aerospace Industries (IAI) President and CEO Joseph Weiss affirmed that budgets and program schedules have fallen behind. IAI "won a competition a couple of years ago" to provide the Brazilian air force with tankers based on the Boeing 767, "but it is not yet on contract. We hope it will be approved soon." Because of IAI's experience with command and control and intelligence, surveillance and reconnaissance systems, the company had been pushing for a share in SisGAAz and the parallel Sis-Fron frontier surveillance system, but these are also delayed.

IAI's Elta unit has a 40% share in Iacit, a Brazilian electronics company, and is supporting development of an over-the-horizon (OTH) radar that will be a key part of SisGAAz because of its range. Ground for the first OTH radar site was broken in March. IAI also has a share in Avionics, a Brazilian company that is promoting a variant of the Heron unmanned aerial vehicle, named Cacador, tailored to Brazil's requirements. (The air force uses the Elbit Hermes 900, delivered by Elbit subsidiary AEL Sistemas, but the federal police fly Herons.)

LAAD saw progress with the JAS 39E/F Gripen fighter program. Saab and Embraer signed an agreement at the show covering joint development of the fighter, and executives expect more details, including how the companies will jointly address the world market, to be settled in the second quarter.

Under the agreement, Embraer will be responsible for multiple work packages across the program, including systems development, integration, flight test and assembly, and will lead development of the two-seat JAS 39F. Embraer Defense & Security CEO Jackson Schneider stressed that the strategic goal is to develop Embraer's expertise in fighter development. "Several hundred" Embraer engineers will join JAS 39 development in Linkoping, Sweden, by year-end, and after 2-3 years return to staff a Brazilian fighter integration center.

The companies agreed that once Embraer's assembly line at Gaviao Peixoto in Sao Paulo state is working, the Brazilian company would build Gripens for export. An agreement defining the worldwide division of marketing, sales and deliveries is slated for this summer, and Schneider expects that Latin America and parts of Africa will be Embraer's responsibility.

AEL Sistemas showed prototypes of the cockpit hardware for Brazil's Gripens. The wide-angle display (WAD) cockpit is under contract for the aircraft, and is the biggest difference between Brazilian and Swedish aircraft. AEL is optimistic that plans will change and the WAD system will replace the JAS 39C-type three-screen cockpit in the baseline Swedish plan.

The WAD system is based on a single 19 X 9-in. display. It comprises two 9.5 X 9-in. units fused together, each with its own power supply, computer and display processor, and either computer/processor chain can drive both displays. The display has touchscreen functions using a matrix of infrared beams. It is coupled with a low-profile head-up display, smaller than that on the Gripen C/D, and the Elbit Dash V helmet-mounted display.

BILL SWEETMAN/AW&ST

A full-size replica of a fuel element for Brazil's planned nuclear submarine—seldom seen in public—was on display at LAAD.

Power Posture

Iran showcases new weapons at annual army parade

M.H. Jahanpanah Tehran

Years of economic sanctions and limited access to the global arms market have not dulled Iran's ability to develop or modify weapons and equipment. At least not based on displays at the annual National Army Day parade here on April 18.

The Iranian army, which includes the air force and navy, but not the Iranian Revolutionary Guard Corps (IRGC), spotlighted new and enhanced weapons at the event. The displays included upgraded versions of aircraft, indigenous air and land platforms, and one new unmanned ground vehicle (UGV).

While many innovations highlight the resourcefulness of Iran's military-industrial complex, most are based on decades-old equipment, some sourced from the U.S. before the revolution of 1979.

The event is one of two military parades held annually in Tehran. The other takes place in late May with all military forces including the IRGC. This is the venue at which Iran's ballistic missiles are displayed.

Army participation this year was not as large as in the past. The air force fly-over, smaller than usual due to changing weather, featured five formations, including two formations of three aircraft each: two F-5Fs and an F-4E. One F-5F was the new Saegheh-2, a modification by Owj Industries, with twin tailfins that flew alongside an F-4E and another F-5F. Another formation featured a Boeing 747-131 tanker escorted by a Mikoyan MiG-29UB, an F-14A and an F-4E. The fifth formation included two Sukhoi Su-24 bombers.

The Fakour-90 air-to-air missile will soon be deployed by the Iranian air force.

Had the air force presence been larger, the public might have seen for the first time a formation of the Saegheh-1/2 aircraft flying new color schemes—Asia Minor II upper-surfaces camouflage replacing blue/gold demonstrator colors, as their service status has changed. It appears as though the Saegheh has finally been given the green light to enter service with the 23rd tactical fighter squadron at Tabriz/Shaheed Fakouri TFB-2 air base.

After the fighters, army aviators did a fly-over with 52 helicopters, among them versions of the Bell 206, 214 and AH-1 Cobra, and Boeing's CH-47 Chinook.

On the ground, the air force displayed indigenous weapons including the AIM-23 Sejil (a reverse-engineered, air-to-air version of Raytheon's MIM-23 Hawk for Iran's F-14s), and the Fakour-90, a long-range air-to-air missile that is almost identical to the AIM-54A Phoenix, which was originally developed by Raytheon. The first successful live-fire test of the Fakour-90 on an Iranian F-14 reportedly took place last year, and the missile is set for production.

Other precision-guided munitions included the GBU-67/9A Qadr, an electro-optic glide bomb; GBU-78 Qassed; AGM-379/20 Zoobin air-to-surface missile; Sattar-4 missile; and an unnamed Iranian land-attack cruise missile.

Iranian ground forces showed a 2 X 2 remote-controlled UGV called Nazeer. There are no official details on the UGV, but it reportedly mounts a 7.62-mm machine gun, two man-portable air-defense/anti-armor missiles, and carries a 600-kg (1,320-lb.) payload. The operational radius for the initial development phase is claimed to be 2 km (1.25 mi.).

The army also unveiled a 4 X 4 wheeled armored fighting vehicle called Aqareb, which seems to be an upgraded version of the Soviet BTR-60 armored personnel carrier, but with a turret-mounted 90-mm gun. It will likely be a reconnaissance and fire-support vehicle. An ultralight tracked vehicle called Fallagh was shown, along with two anti-materiel rifles, the 23-mm Baher and 14.5-mm Shaher.

Artillery rockets included the Fajr-5, Naze'at and Zelzal.

The air defense force showed four weapons: the S-200VE/SA-5 surface-to-air missile (SAM); Shahab Thaqeb HQ-7 (FM-80) short-range SAM; Mersad low- to mid-range system, a reverse-engineered version of the MIM-23B I-Hawk; and the Bavar-373 advanced long-range SAM that resembles the 5V55 missile in the Russian S-300 air-defense system.

M.H. JAHANPANAH / AW&ST

The Bavar-373 was displayed for the first time last summer as the fourth member of the Sayyad family of air-defense weapons. Despite the "family" classification, the weapons have little in common. Sayyad-1 is based on the HQ-2, a Chinese copy of the Soviet S-75 Dvina missile; Sayyad-2 is derived from the RIM-66 Standard MR (medium-range) missile Iran acquired from the U.S. in the 1970s; Sayyad-3 is of unknown origin; and Sayyad-4 is the Bavar-373.

Brig. Gen. Mohammad Mahmoudi, deputy army commander for executive affairs, said recently that the Bavar-373 is not operational and no final tests have been set. The weapon was developed to replace the S-300 missile defense systems that Iran planned to buy from Russia until Moscow canceled the contract in 2010. President Vladimir Putin recently agreed to supply S-300 systems to Iran, although Russia's TASS news agency on April 23 reported that delivery is not "a matter of the near future."

Rep. J. Randy Forbes

Chairman, House Armed Services seapower and projection forces subcommittee

Age: 63

Education: B.A., Randolph-Macon College, 1974; J.D., University of Virginia Law School, 1977

Background: Served in the Virginia House of Delegates from 1989 to 2001; has represented Virginia's 4th District in Congress since 2001. Served on the House Armed Services Committee for the past 14 years.

Personal: Married, with four children

Measure Twice, Cut Once

Rep. J. Randy Forbes (R-Va.) is a leader in pushing higher-end capability for the U.S. Navy's planned Unmanned Carrier-Launched Airborne Surveillance and Strike (Uclass) system, preferring a stealthy, penetrating strike capability to a pure intelligence, surveillance and reconnaissance aircraft. Forbes discussed his views with Defense, Space and Security Managing Editor Jen DiMascio and Senior International Defense Editor Bill Sweetman.

Defense Technology International: **Every stealth program seems to blow up on cost and schedule. Can you sell a carrier-based unmanned bomber?**

Forbes: We have to ask whether this is strategically necessary. If so, the second question is how we deal with keeping costs reasonable and manageable, and how we allocate the dollars. We have the same concerns about cost overruns and requirements creep when we buy new technologies in almost every platform. For our carriers to be relevant 20, 30 or 40 years down the road, we have to make certain we have got the right carrier strike group (CSG).

There is a hierarchy of needs that have to be addressed. And when you look at that strategically, it is almost impossible, given the new anti-access, area-denial (A2AD) environment, to suggest we can do that without a deep, penetrating strike capability. Uclass offers the ability to do that. Controlling costs and delivering the system we need are doable.

What must we do to afford it?

One reason I am a strong supporter of the Office of Net Assessment is that we need to go back to strategic thinking that's more than a six-month, knee-jerk reaction. We have for the last several years planned Navy air wings and most of our air capability based on the fact that we have a lot of short-range sorties in a permissive environment.

That's not necessarily the case down the road. We're not just talking about China or Russia; we're talking about the proliferation of [A2AD] systems to other countries. Once we do that strategic thinking, it puts a plethora of capabilities on the line. Then everyone realizes it's not just whether you want one particular system.

You're looking at a holistic approach. No one platform can penetrate A2AD systems. I may change the number of Growlers I have if I can buttress that capability somewhere else. I may change something the Navy has for missile defense if the Army has a land-based missile they can use. In recent years we've looked at things and asked: 'How much money do we spend?' We've developed our strategy more according to the acquisition process than the other way around.

If one program, the F-35, costs $15 billion per year in the 2020s, does that leave room to innovate?

Part of making the F-35 affordable is recognizing that every time we decrease our buys our allies have a correlated decrease and the price goes through the roof. At some point we have to say if we need F-35s or another platform, how do we create a system where we are not starting it, stopping it, and starting it again and creating cost spikes?

Some have said that the backstory to the high-end Uclass includes the X-47B and at least two classified land-based operational UAVs. Does that hinder decision-making?

We walk an interesting line between someone who may be hiding behind the term 'classified,' and where secrecy is really essential. When it comes to Uclass, we can have an adequate debate by looking at the requirements we know about. It is not about transparency but whether we choose the right priorities. When we look at weapon systems like [China's] DF-21 [anti-ship ballistic missile], you don't need a lot of transparency to know that's going to push our CSGs back almost 1,000 mi. If we don't have a long-range, deep-penetration capability it's going to be difficult for the CSGs to do what they have to do.

During this year's markup, are you proposing anything more prescriptive for the Uclass program?

We never tell the Pentagon, 'These are requirements you need.' What we try to do is make sure they measure twice and cut once, and get the requirements correct.

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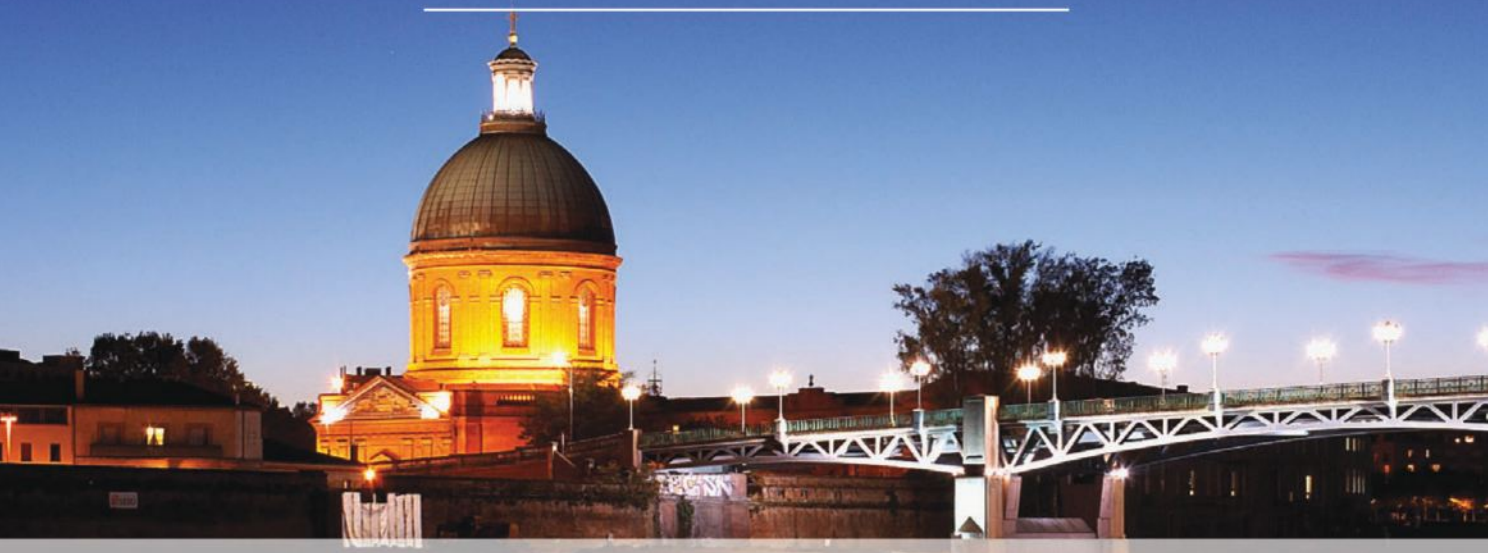

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Sea Change

With land coverage well in hand, Flightradar24 takes to the oceans

John Croft New York

A test this summer in the Baltic Sea east of Stockholm will begin to define the future for the exponentially growing, crowd-sourced, global surveillance network that goes by the name of Flightradar24.

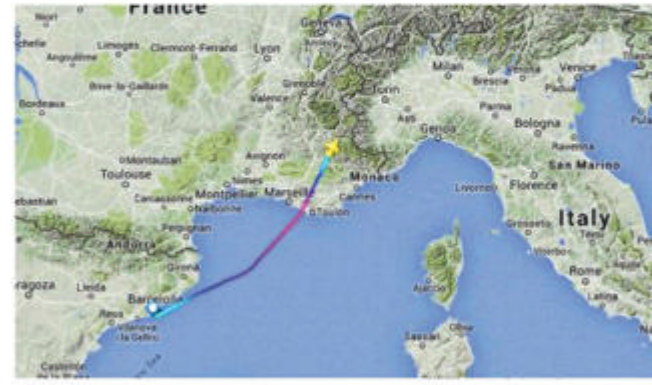
The service that started on a lark—with one Kinetic Avionics Automatic Dependent Surveillance-Broadcast (ADS-B) receiver in 2006—now covers about 80% of the world's landmass with more than 6,600 receivers, expanding at the rate of 50 new receivers installed every week, and is the largest among a growing number of privately owned aircraft surveillance networks. The receivers, many provided at no cost by Flightradar24 and placed at homes and businesses of ardent supporters, capture the position and identification outputs from ADS-B avionics now on an increasing number of airliners, business jets and most other aircraft. About half of the receivers today also track aircraft carrying legacy Mode S transponders using a form of triangulation called multilateration.

Even when practically all of the Earth's landmass has coverage, a feat Flightradar24 hopes to complete this year, co-founder Mikael Robertsson points out that roughly 70% of the globe—the oceanic domain—will still be largely in the dark when it comes to surveillance, even with stations placed on as many islands as possible. His company plans to play a prominent role in the race to open up the oceans to low-cost tracking of aircraft, and a search for potential solutions starts in part with the Baltic Sea test. "Our goal is now to cover the world," says Robertsson.

Speaking to Aviation Week in New York in late January, Robertsson was scant on details but said the test will look at the performance of ADS-B receivers attached to buoys, a relatively low-cost solution the company could fund on its own. If successful, the test could lead to fleets of buoys in captive locations throughout the oceans or left to slowly free-float on the currents between continents. Other technologies under consideration include balloons and space-based receivers. Robertsson says the company is talking with "one partner" about space-based systems. He confirms that partner is not Aireon; that company plans to go live in 2018 with a network of space-based ADS-B receivers funded by a group of air navigation service providers.

For many other companies, such a lofty goal might be eyed with suspicion, but given the meteoric rise of the passive surveillance network, fueled by two co-founders with no insider experience in the aviation industry, Flightradar24's plans may hold water.

Robertsson and Olov Lindberg happened upon the idea for a flight-tracking company after developing and launching an airline price-comparing website, Sweden's version of Kayak, in 2006. "We became the biggest price-comparison site in the Swedish market in just one year," says Robertsson. They bought the Kinetic ADS-B receiver to play around with and decided to post screen shots generated by the receiver's software updated every 60 sec. as a free subpage to their



FLIGHTRADAR24

Flightradar24 published its tracking data for Germanwings Flight 9525, which was later augmented by autopilot commands made in the cockpit to initiate the fatal dive.

Svenska Resenatverket AB price-comparison website, called Flygradar, starting in 2007. He and Lindberg sold the price-comparison site in 2014.

At the time, Robertsson estimates that 40-50% of the aircraft overflying their Stockholm location were equipped with ADS-B. "We made [Flygradar] just to get more traffic into the price-comparison site, but then the subpage became more popular than the [main site], so we registered a separate domain—Flightradar24," he says. At the start, Robertsson and Lindberg had contacted enthusiasts around Europe who already had their own receivers, sending them software that would upload the tracking data to Flightradar24's servers. They launched the new site in 2009 with "eight or nine" receivers connected to that server. In 2010, they published their own applications with data plotted using Google maps.

The idea caught on quickly, with owners of more receivers contacting them for a copy of the software. In less than six months, Robertsson says, the whole of Europe was covered. The timing was fortuitous. In April 2010, the Eyjafjallajokull volcano erupted in Iceland, cutting off air traffic and sending onlookers to Flightradar24 to get the big picture. "They showed our map on CNN and BBC, and all the biggest news channels were using our maps," says Robertsson. The interest generated web hits—4 million in one day in April 2010. "That's when we understood that this was more than a hobby project," says Robertsson. Network expansion accelerated and by 2012, Robertsson and Lindberg hired former Lindberg classmate and Internet entrepreneur Fredrik Lindahl as the CEO to split Flightradar24 into a separate company.

There were 500 receivers in the network, and the company had just signed an agreement with German electronics manufacturer Gunter Kollner Embedded Development to produce its own branded receivers. "In less than three years since then, we went from 500 to 5,500 receivers," says Robertsson. Those receivers cover practically 100% of Europe and North America, all of Japan, and 80-90% of South America. Coverage in Asia, Russian, India, Pakistan, the

Middle East, Thailand and Malaysia is growing fast, he says.

China has been more problematic, with the country essentially barring the service by blocking an essential ingredient—Google maps. Chinese search engine provider Baidu launched "a copy" of Flightradar24 a few months ago using flight-tracking data from within the country. "They don't have issues with the data itself, it is more that they want to do it by themselves and not have a Western company doing it for them," he says of a surveillance service. Regardless, Robertsson says contacts are in place to get more of China covered this year, potentially with alternatives to Google maps.

Africa, by contrast, has been problematic because of power interruptions. Robertsson says whereas globally about 90% of receivers are operating at any given time, in Africa the number is 25%. "We are investigating all options [for Africa]," says Robertsson. Included are satellite-based Internet and solar panels and wind energy to keep the receivers powered. The company is also studying a next-generation ADS-B receiver with integrated antennas.

Privacy advocates will be pleased to know that Flightradar24 charges no fees to block the tail numbers of business jets based on an internal list of aircraft types the company put together, as well as the FAA's list of blocked tail numbers, and direct requests from operators.

The cost of shipping 50 new receivers a month, at $400-500 each, eclipses the salaries of the small staff, says Robertsson. Even so, the company has been profitable through a combination of advertising, IOS (Internetwork Operating System) and Android application sales and premium service on the website. Revenue from one-time application downloads continues to rise, in part when customers switch between phone platforms, and new apps are being built, but the company is putting more resources into new options for the web version, for which subscribers pay a monthly fee. The current rate for the single "premium" option is $2.99 per month paid one year in advance. There is a free web service, but it has advertisements and times out after 15 min. Robertsson says the company has a "very, very long road map" for new features for both the apps and the web pages, as well as "quite a big update" for the web coming soon, with four different premium levels avialable.

While already profitable, Flightradar24 is exploring new business-to-business models. "The company has been 100% funded by me and Olov, and it has been profitable since Day One," says Robertsson. "But it is not a good business model. People buy the app for $3 and some people bought it 3-4 years ago and we do not get any more money from that." As of mid-February, Robertsson says, the company had sold 3-4 million applications and was honoring 10-15 "free ups" on the web, with the numbers of both growing.

Potential B2B paths could include more licensed sales of data to airlines, an option that three major non-U.S. airlines use in their operations centers, but one that Robertsson says is not profitable today. "It could be our future, but today we have only a couple of them," he says. "It does not even cover the cost of selling [the data]." Competitor FlightAware, which is now building its own network of receivers, has teamed with both SITA and Rockwell Collins as a data provider for those companies' surveillance and data services for airlines and business jets.

To the broader question of quality control for a crowd-sourced surveillance system, Robertsson says about 95% of the receivers sent out come online and about 90% remain online. Hosts are granted free access to the premium service offering.

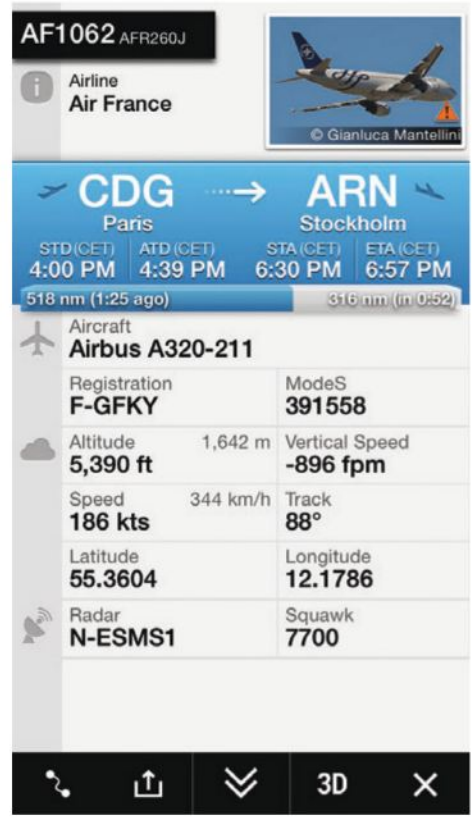
"The incentive for most people is just better coverage. That's enough for most people," he says.

Better coverage also stems from the increasing number of receivers with multilateration capability to track non-ADS-B-equipped aircraft. Health of the ground network is monitored by a team of five employees who have a "daily routine." If a receiver goes down for more than 6 hr., an email is sent to the host asking about the problem. After 72 hr., an email goes to customer support, and they try to contact the host. Those contact attempts continue for two weeks. "If the receiver is not online after one month, we ask the host to send it back," says Robertsson.

"Most" airlines use its website or applications in some form or other, and the web page has been tracked by IP address to airlines or has been spotted in the operations centers or in promotional videos for dozens of airlines, Robertsson says. On EasyJet's website recruitment page, "they [feature a] guy sitting at desk working on Flightradar24," he says. "It feels good that they have a tool that they can track their aircraft with."

However, it has proven difficult to monetize that affection. Robertsson says his company has reached out to "many, many" airlines with samples of B2B products, only to be turned down due to cost considerations. "We say $1,500 per month and they say, 'No chance—we'll never pay $1,500 if we can get it for free on the net.' Then it's not so fun."

Another hindrance is Robertsson and Lindberg's lack of an aviation background. They have not used the tracking tools airlines use nor do they know what systems are popular. That is both a plus and a minus, says Robertsson. "If you're used to using a tool and start a new company, then maybe you try to make a copy of the tool you used in a previous company. But here we [have a clean slate], so we are creating something new."



FLIGHTRADAR24

The application features automated alerts when an aircraft issues a radio failure or flight emergency transponder code, as shown for this Air France A320 heading for Stockholm on March 13.

Dining On Leftovers

Hainan Airlines wants a fleet of at least 49 long-haul aircraft by the early 2020s

Bradley Perrett **Beijing**

When the government decides which airline can fly where, it helps to be a government airline. With that advantage, China's top three carriers enjoy such strong international markets, such as Beijing to Frankfurt and Shanghai to Los Angeles, that they can deploy big aircraft, Boeing 777-300ERs.

Hainan Airlines, privately owned and ranked fourth in the industry, must make do with slim pickings. The obvious aircraft for its restricted intercontinental routes, all long and thin, is the 787. The carrier has 10 787-8s in service, says it will buy 30 787-9s and, according to an industry official familiar with its plans, wants to lease at least six more -9s, to get that version into service as soon as possible.

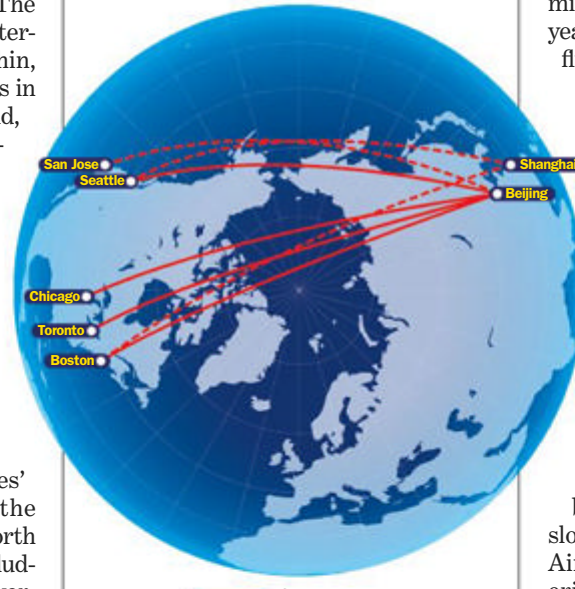
With only leftovers to dine on, Hainan Airlines is doing its best to make itself a decent meal. This year it will have more North American routes than any of its rivals except Air China, the country's leading international carrier.

The sheer size of Hainan Airlines' intended long-haul fleet shows the scale of its ambitions for serving North America, Europe and Australia. Including nine A330-200s that are, on average, about four years old, the carrier apparently intends to have at least 49 long-haul aircraft in service in the early 2020s, assuming the leased 787-9s are returned. By comparison, Air China has 81 long-haul aircraft in service or on order, including Boeing 777-200ERs and 747-400s that cannot have much life left. China Eastern has 50, and China Southern Airlines 45.

Admittedly, the top three have generally larger aircraft and, according to another industry official, are negotiating for widebodies; they will probably place orders this year. So their long-haul fleets will expand as Hainan Airlines' does. But each of those carriers is about three times bigger than Hainan; presumably, they will not have long-haul fleets three times bigger.

Hainan Airlines said in 2013 that North America would be the focus of its international expansion for 2-3 years (*AW&ST* May 20, 2013, p. 36). By the end of 2014 it had four services to North America, all from Beijing, its main base. In June it will open three more. Two will add Shanghai connections to U.S. cities already served from Beijing—Boston and Seattle—while the third, linking Beijing and San Jose, California, intrudes into the Bay Area market Air China serves with flights between the Chinese capital and San Francisco.

Hainan Airlines' North American Expansion



Source: iStock/Hainan Airlines

These markets may be better than what Hainan Airlines can normally expect as scraps from the table of the big three. Those carriers, lured by the strong European tourism market, have not paid enough attention to the U.S., says a senior executive at an aircraft leasing business who consistently analyzes the industry. In the past few years, the market for travel between China and the U.S. has grown strongly, he adds. So Hainan could hardly be making better long-haul moves.

But they may not be good enough. The leasing executive, a former manager at Hainan Airlines, doubts that any of the carrier's U.S. operations are making money, except maybe the one between Beijing and Seattle. The airline suffers from having no alliance membership, he points out.

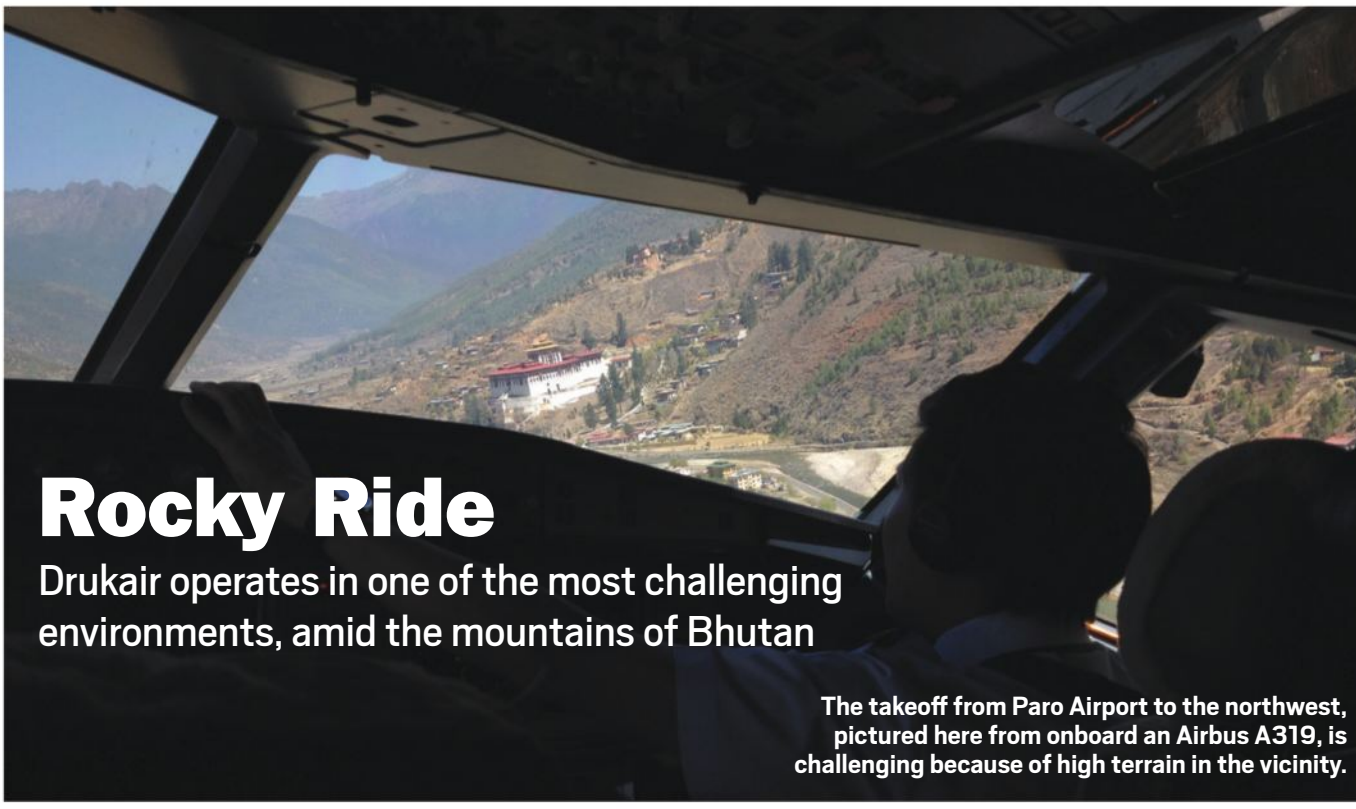
North America is not the carrier's sole focus. It announced two other new services this year: Beijing-Tel Aviv and Chongqing-Rome, the latter presumably enjoying support from the Chinese city's government. A service between Beijing and Birmingham, England, is planned this year, perhaps beginning with charter flights, says an industry official.

The intention to order 787-9s was announced to the Shanghai stock exchange but no contract has been confirmed. The airline is negotiating with General Electric and Rolls-Royce for engines, says a fourth industry official. Its 787-8s have GEnx engines.

Deliveries of the aircraft will be prompt. The airline says they will begin before 2021; an industry official says they will be completed by that year. This is possible because some of the production slots were first allocated to United Airlines. United had been considering switching its buy for 787-9s to 777s. It seems to have done so; it has now ordered 10-300ERs and Boeing says an unnamed customer has canceled 10 787-9s.

Hainan's 787-9s are not coming soon enough, however, which is why the airline wants to lease at least six more.

The leasing plan suggests that Boeing has failed to persuade Hainan to buy the terrible teens—at least 10 early-production 787-8s that are overweight and therefore cannot meet performance specifications. Boeing was marketing the aircraft, so named because of their manufacturer's serial numbers, to the Chinese carrier about a year ago.



JENS FLOTTAU/AW&ST

Rocky Ride

Drukair operates in one of the most challenging environments, amid the mountains of Bhutan

The takeoff from Paro Airport to the northwest, pictured here from onboard an Airbus A319, is challenging because of high terrain in the vicinity.

Jens Flottau Paro, Bhutan

For most airlines, flying is the easy part of the job—competitors, high costs and falling yields are the big challenges. Bhutanese national carrier Drukair faces these obstacles as well, but for it, flying is not easy either.

Drukair operates out of what many consider the most difficult mountain airport in the world, its home base in Paro, at an altitude of over 7,200 ft. There are high mountains not only to either side of the narrow runway but at both ends of it as well. Drukair and its new competitor, Bhutan Airlines, can operate only under visual flight rules, and the Airbus A319 is the largest aircraft able to operate into Paro. In the spring, afternoon winds are so strong that the airport has to shut down at noon every day. And in other seasons, the weather can be so bad that flights are often canceled. Drukair asks its passengers to allow at least 24 hr. of connecting time at international gateways in case aircraft have to be held on the ground until the weather improves.

For 30 years, Drukair has been providing the only air link from Bhutan to the outside world. The carrier started scheduled services with a Dornier Do-228 from Calcutta in 1984, and then added a single BAe-146, its first jet. Ten years later, its first Airbus A319 arrived. In March, Drukair took delivery of its third owned A319, the first one with sharklets. It will replace a leased A319, which will be returned to the lessor in July. In addition to the four A319s, Drukair flies one ATR 42-500, mostly to Bumthang, Bhutan; Kathmandu in Nepal; and Calcutta. Bumthang is its only domestic destination; others are under consideration, but there are significant infrastructure limitations.

The new aircraft not only lowers the average fleet age, but also has significant benefits, given the harsh operating environment. Because of the high altitude of Paro Airport, the aircraft must be severely weight-limited on departure. An A319 without winglets would not be able to carry more than 80 passengers out of Paro on the Bangkok flight, which takes little more than 2 hr. Whether the aircraft can make it to New Delhi—which is closer—with a full passenger load depends on the temperature on departure. A refueling stop is often needed in Kathmandu or Bagdogra, India. Drukair flights to Bangkok and Singapore now stop in Bagdogra or Guwahati in India to pick up additional passengers, even though these stops are hardly economical.

Because of the enhanced operating characteristics of the sharklet-equipped A319, the maximum takeoff weight from Paro can be increased by 1.8 tons. That translates into at least 10 additional passengers as well as more fuel and range. Nonstop flights to Bangkok are becoming economically more feasible. But Drukair CEO Tandin Jamso says the airline will take a close look at the A319neo in a few years. According to Airbus's projections, the A319neo would enable Drukair to carry 10 more passengers on Paro-Bangkok flights than it does in the current sharklet-equipped A319, allowing it to operate with almost a full load. And it would be possible to operate to New Delhi nonstop, without the expensive refueling stop in Bagdogra or Kathmandu.

Drukair's A319s are configured with 118 seats in a two-class layout. They are equipped with CFM-56 engines rated at 27,000 lb. thrust, which is normally applied only on the larger A320. "These are A319s with A320 engines," says Thomas Friedberger, senior vice president of sales for Airbus in Southeast Asia. Before Drukair first took delivery of the A319s in 2004, Airbus sent teams to Bhutan to map the surrounding high terrain and develop useful arrival and departure procedures.

The weight limitations are not the only factor making Drukair's daily operations challenging. The A319s fly an average of only 5.5 hr. per day and the ATR even fewer. In theory, high yields would be needed to compensate for the

low utilization of its aircraft to make the company economically viable. But even that is now no longer really possible, since privately owned Bhutan Airlines started flying scheduled services using two A319s, competing head-on with Drukair on the Bangkok route.

Bangkok is particularly important for the airline because of the many international long-haul flights that tourists can connect with there.

With the additional capacity the new aircraft bring, Drukair plans to temporarily increase capacity on existing routes such as to Singapore and New Delhi, rather than expanding the network. The airline had been profitable until 2013, but recorded a loss in 2014 as a result of the new competition from Bhutan Airlines, which offers much lower fares. Yields dropped by as much as 15% systemwide. "And 2015 does not look so good either," Jamso concedes. The current CEO has recently announced his resignation "for personal reasons," but will continue in his post until a replacement has been found.

With the help of an outside adviser, Drukair has launched a transformation program to make its operations more efficient. The company's large overhead is also a thorny issue that needs to be addressed, company sources say. The carrier belongs to government-owned Druk Holding Investments (DHI), which controls the largest public-sector companies in the country. Drukair will always be able to rely on government support in case of financial trouble because of its strategic importance, connecting Bhutan to the rest of the world. And even in years when the airline does not make a profit, its contribution to the economy is still positive because of the business it generates for tour operators, hotels and other businesses.

Nonetheless, DHI is pushing hard to eliminate bureaucracy and adopt industry best practices. It also sees Drukair as a showcase for how a domestic company can benefit from its international exposure and would like to apply what the airline has learned to its other shareholdings.

As part of its drive for efficiency, Drukair has abandoned its Mumbai flights, which "did not develop as well as we thought," Jamso says. The route will only be offered on a charter basis in the high season. A large part of the company's business comes from package tours in connection with tour operators and hotels, which is the only way tourists may enter the country.

What to do with its lone ATR is another question that needs to be answered. On the one hand, a one-aircraft fleet is hard to justify economically. But it does give Drukair the flexibility to change it to an A319 route if demand is low or an aircraft goes out of service. The ATR typically flies to Calcutta, Kathmandu and Bumthang. So "we may need a second ATR," Jamso says.

Drukair currently only has one domestic route, a 35-min. sector from Paro to Bumthang in the north of the country. The field is at an altitude of over 8,000 ft. and has a narrow runway on which the aircraft is parked during its down time because there is no apron. Drukair would like to provide more air service to Bumthang—the region is called the "Switzerland of Bhutan" because of the beautiful scenery. It is even looking at deploying the A319 on the route to be able to add more capacity, but that would require lengthening the runway and broadening turn areas at either end of it, so the deployment is unlikely in the short term.

Bhutan's road network is only well-developed near the capital, Thimphu, and the international airport in Paro. There are no roads in the north—where the highest peaks are located—and only few in Central and Western Bhutan. A trip across the country by car can take several days. Therefore airfields in Gelephu (to the south) and Trashigang (to the east) are on the list for upgrades to at least allow ATR flights.

The airline is also planning to become a more integrated part of the international air transportation network, signing up to become a member of the International Air Transport Association (IATA) in 2014, to gain access to the IATA clearing house. That is a prerequisite for more interline agreements, one of which it already has in place with Thai Airways. Because of the stringent Indian visa requirements, Bangkok is the nearest large international transfer point for flights to Bhutan. But Jamso would like his airline to add similar agreements with Singapore Airlines or Korean Air as soon as the third quarter of this year, giving it "the advantage of a wider sales network." Drukair itself has "no plans to go long-haul" and there is no way it could use widebodies at its home airport. Instead, code-sharing could soon become another way to attract more long-haul travelers.

Tourist arrivals are up, but in accord with its general policy of sustainability, Bhutan is aiming at slow single-digit percentage growth rates and targeting high-end private travelers only. Tourists are required to sign up for packaged arrangements that cost at least $200 per day, per person. Drukair's future growth not only hinges on crucial airport infrastructure development, but also on the availability of hotels and lodges, more of which are now being built.

Drukair has taken delivery of its first Airbus A319 with sharklets, which offer a better takeoff performance at Paro.

JENS FLOTTAU/AW&ST

MULTITASKING TEST

Jens Flottau Paro, Bhutan

Drukair operates into one of the world's most challenging airports. Unpredictable weather, the high altitude of Paro Airport, surrounding mountains and the lack of navigational aids make good pilot training paramount for a safe operation.

The national airline of Bhutan is one of only two airlines that fly into the country's sole international airport. The field is situated in a narrow valley at an altitude of 7,350 ft. The mountains nearby are up to 15,000 ft. high. The runway is 7,430 ft. long and 98 ft. wide. With only a VHF omnidirectional range (VOR) and distance measuring equipment (DME) in the vicinity of the airport, all approaches and departures have to be flown according visual flight rules. There is no margin for error: The valley is so narrow that whenever an aircraft approaches for landing or is about to take off, the road along the airport fence is closed by police.

Bhutan's Paro Airport is situated in a narrow valley surrounded by high peaks, making visual approaches challenging.

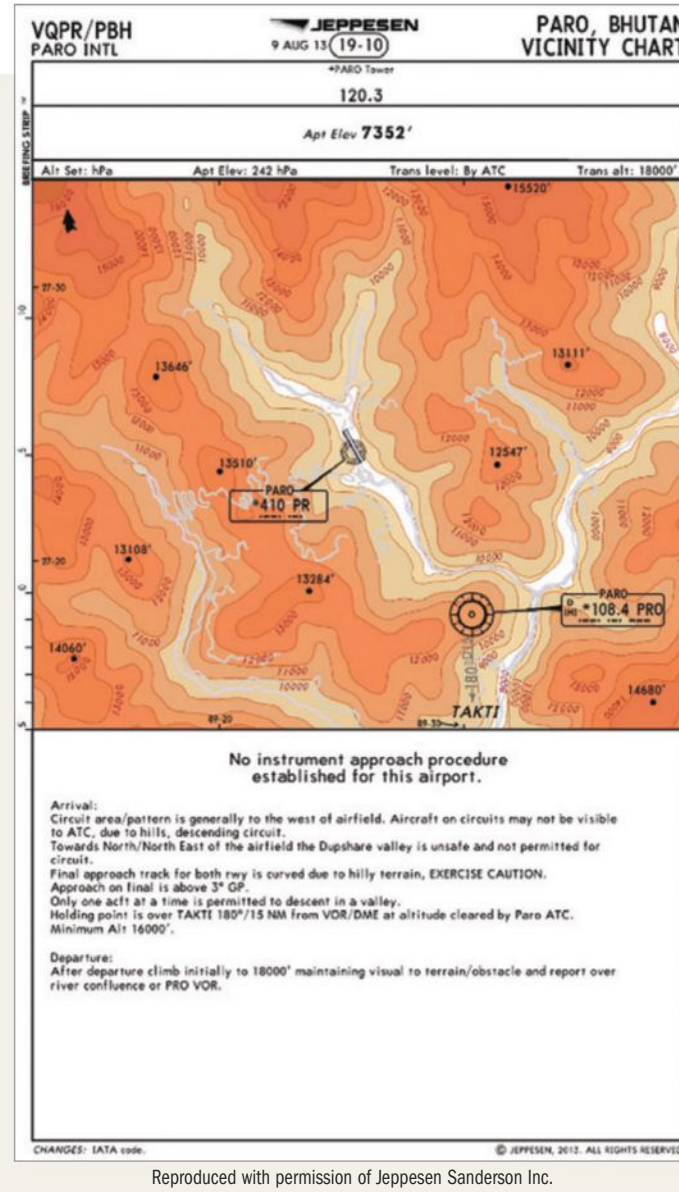
"You have to know the landmarks and you always have to have an escape plan," says Sonam Tobgay, a senior training captain for Drukair.

In theory, landings and takeoffs are possible in both directions for what is designated Runway 33 and 15. But "we try to avoid this [15 approach] as much as possible;" says Tobgay. It is a very tricky maneuver. Aircraft attempting to land must fly over peaks around 13,000 ft. high in the immediate vicinity of the airport and then go for a circling approach into the Dupshare valley. There is no way to line up with the extended runway centerline early because there is a hill literally a few hundred feet northwest of the runway. "We have to level the wings, flare and reduce power at 50 ft. simultaneously," Tobgay says. "It is real multitasking."

The approach for Runway 33 is a little less challenging because there is more time to follow the curved valley down to the threshold and a few more seconds to align with the runway.

Takeoffs are equally tricky, particularly when provisioning for one-engine-out scenarios. An engine failure at takeoff from Runway 33 would be the worst case: "If you respect your procedures, you can make it," says Tobgay. Respecting procedures here means going into takeoff-go-around mode immediately, retracting the gear, then following a visual departure path that is designed to gain as much altitude as possible. The problem with that takeoff is that there is no escape from the Dupshare valley, which is surrounded by mountains exceeding 16,000 ft. It is possible to make a turn back to the airport inside the valley, but only at a sufficient altitude.

Aircraft taking off toward the southwest have the advantage of being able to follow the valley with one engine out and then turn right, following another valley until it becomes wide enough for the turn at a lower altitude.



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Because Paro is such a challenging airport, only captains are allowed to fly into and out of it. And they, too, have to go through extra training before they are approved for line operations. There is a special simulator for training to become familiar with the conditions, followed by the so-called valley checks. Any new captain has to fly 30 sectors under supervision.

But terrain alone is not the only issue in Paro. From February to May, it is essentially impossible to fly in the afternoon. Winds as strong as 80-90 kt. hit the mountains and cause severe turbulence during the valley approaches. Sometimes the wind does not even allow operations in the morning. Aircraft coming in from New Delhi or Bangkok often divert to Bagdogra in India "and wait it out," as Tobgay says.

Video Watch from inside Drukair's latest Airbus A319 as it navigates close to mountains en route to Paro Airport—tap here in the digital edition or go to **AviationWeek.com/Drukair**

AVIATION PERFORMANCE SOLUTIONS

Delta Air Lines is sending its senior simulator instructors to a one-week school for upset training, including 4 hr. of in-aircraft experience and two full-flight simulator sessions.

Upset Ultimatum

Delta gets jump on 2019 pilot-training mandate

John Croft Washington

Delta Air Lines is giving its senior instructor pilots a one-week all-attitude flight-training immersion to help the carrier develop new full-stall and upset-recovery training programs for line pilots. The upset-prevention and recovery-training (UPRT) course includes ground, in-aircraft and full-motion simulator instruction aimed at helping the airline better prepare its line pilots to avoid loss-of-control (LOC) accidents, which are often preceded by stalls or upsets.

The move comes ahead of an FAA mandate that will require airlines to provide pilots with UPRT as well as full-stall recovery demonstrations by March 2019. Delta's pilots now receive approach-to-stall and upset-recovery training in simulators, but the rule will require deep-stall demonstrations up to an angle-of-attack of 10 deg. beyond the stall, requiring a companion upgrade to simulator aerodynamic models. "Given the FAA's new pilot qualification rules and the extended simulator envelope for full-stall training, we wanted to make sure we were out in front of this," says Jon Tovani, the airline's managing director of flight training. "This is very exciting training for the industry because, to date, everybody is pretty squared about what has to happen as the aircraft approaches a stall, but we've had some unfortunate real-world occurrences that suggest pilots are less able to recognize fully developed stalls and then recover from them."

The mandate, finalized in 2013, is one of several rule changes spawned in part by the 2009 LOC crash near Buffalo, New York, of a Continental Connection Bombardier Q400 turboprop operated by Colgan Air. The training has also been identified as a key LOC intervention by the Commercial Aviation Safety Team (CAST), which is asking for airlines to provide UPRT and approach–to-stall recovery procedures using realistic scenarios, including situations where the pilots are reading unreliable airspeed on the instrumentation and the aircraft approaches a stall with the autopilot engaged.

So-called Safety Enhancement 196 is one of 19 interventions that the government and industry team determined would have helped prevent 18 fatal LOC commercial aviation crashes between 2003 and 2012. The group identified training as a significant theme in nine of those accidents. The FAA recently released an Advisory Circular detailing the recommended training needed for an effective airline UPRT, based in part on the CAST analysis and the findings of an international LOC avoidance and recovery training group.

Delta, the first U.S. major to announce third-party training services for its instructors ahead of the mandate, plans to develop its own in-house type-specific full-stall and upset-recovery program after all 16 of its senior instructors—two instructors per aircraft type in the fleet—have completed the non-type-specific program this summer. "Each of these teams of two will come back and elevate their programs to new levels," says Tovani. "Our training and everyone else's will change in that we will show pilots what a stall looks like if the aircraft were to enter a stall, and what to do to get out of that."

To date, four instructors have completed the one-week Jet Upset Simulator Instructor course offered by Aviation Performance Solutions (APS) near Dallas.

The course includes 10 hr. of ground training, four 1-hr. flights in an Extra 300 tandem-seat aerobatic aircraft and two sessions in a Level D transport-category full-motion aircraft simulator. The Extra 300 in-aircraft training is used in part to introduce pilots to the visual sensations, G-forces and control inputs experienced during all-attitude maneuvers as well as various upsets and recoveries in aircraft that are economical to operate and built to safely withstand high G-loads. Tovani says most of the instructors being sent to APS do not have previous all-attitude flight training, which is typical for civilian-trained pilots.

APS has contracts for similar training for South African Airways instructor pilots and those of three other airlines which the company has not identified. "We are either scheduling, or have proposals out to 17 other airlines," says APS President Paul "B.J." Ransbury. Competitors for the third-party services include Flight Research of Mojave, California, and Calspan of Buffalo, New York.

Tovani says Delta has a "long-term relationship" with APS that will include Ransbury's UPRT experts conducting interim audits of the final program the airline deploys. "They'll make sure we've stayed within the bounds of what they know to be the actual science behind upset recovery," says Tovani.

Synthetic Safety

Path is clearing for synthetic vision on airliners

John Croft Paris

Virtual reality will make its way into commercial airliner flight decks in the next five years as part of a voluntary safety upgrade movement spurred by a government/industry Commercial Aviation Safety Team (CAST).

Synthetic vision, a 3-D rendering of runways, terrain and obstacles that gives pilots a sunny-day virtual view of the flightpath, is already standard for new general aviation and business jet cockpit displays and even for many portable devices, but it is not yet available in the cockpits of modern jetliners.

Along with an "optical flow" that artificially creates a sense of aircraft movement, synthetic vision systems (SVS) can also include energy awareness cues including a flightpath vector and acceleration/speed-error indicator—aids safety advocates say can help eliminate attitude excursions that may lead to upsets and loss-of-control accidents.

CAST, a grouping of FAA, airline and industry safety officials, was formed in 1998 to tackle reducing the risk of fatal accidents on U.S. commercial airliners by 80% by 2008, a goal it has largely met. CAST regrouped in 2011, with the aim of cutting commercial airline fatality rates by an additional 50% by 2020. Loss of control has by far been the largest underlying factor in fatal accidents since 2003.

The group analyzed 18 airline loss-of-control accidents or incidents in 2003-12 and determined that a "virtual-day" visual meteorological conditions (VMC) display, aka SVS, could have aided pilots to avoid 17 of the 18 events where there were no external references to help orient the aircraft.

In part because of the optical flow of the elements in a scene, SVS provides an intuitive sense of orientation, motion and ground closure rate compared with the legacy blue-over-brown attitude display. By adding energy guidance to an SVS display, CAST determined that the risk of a loss-of-control accident can be reduced by 16%, assuming 30% of the global airline fleet is equipped by 2035.

However, SVS technology, first FAA-certified for transport-category aircraft in 2006, has not yet made its way to airline cockpits, aside from a few aircraft with retrofit avionics upgrades. Manufacturers have some concerns that by offering synthetic vision without a mandate, it could appear that they have ignored an essential safety tool other sectors put in place years ago.

The CAST initiative solves that problem for OEMs; CAST endorsements have nearly the same clout as a mandate so airframers are apt to voluntarily implement them—in this case, installing SVS in the form of a virtual-day VMC display in new aircraft by 2020.

Airbus, Boeing, Bombardier and Embraer have already committed to a separate CAST request to begin including the three energy-state cues into the primary flight display (PFD) information on new-build aircraft by 2018. However, before implementing the virtual day-VMC display Boeing and Airbus have asked for more guidance regarding implementation and the certification risks of doing so, a request the FAA is in the process of fulfilling via RTCA Special Committee 213 (SC213).

SC213 primarily develops consensus-based general and performance requirements as well as system performance-verification guidelines for sensor-based systems or, with members representing a diverse mix of regulators, airframers and avionics providers. The FAA asked the group to devise minimum system performance standards for the virtual-day VMC displays by June 2016, a date that may be overly optimistic.

During its first discussion of the task at a meeting in Paris in mid-April, the complexities of the request and potential unintended consequences began to take shape. While simple in concept, implementation of the virtual-day VMC display is far from settled.

One preliminary concept includes a display of SV terrain and obstacles for all attitudes, a depiction of the runway of intended landing, and recovery guidance that could give a pilot visual or aural cues as to which way to roll or pitch the aircraft to bring the wings back to level attitude. The virtual scene is to be available on the PFD at all times for both pilots.

HONEYWELL

Synthetic vision systems, widely available for the primary flight displays in business-jet cockpits, could soon be coming to airliner flight decks.

Key elements to be determined through continued research include how to show unusual attitudes and whether recovery cues should be included; how best to show and measure the optical flow of the scene; the required minimum display size, field of regard, compression ratio and resolution; and what color cues work best. Still open for debate is whether the VMC display would be shown on head-up displays.

One key point is whether the SVS, now certified as a situational awareness aid only, would require more scrutiny if it becomes a pilot's primary tool to recover from unusual attitudes.

Today, regulators require or recommend that the flight guidance in an upset attitude revert to blue-over-brown with arrow cues showing the direction to recover. However, some SVS developers say leaving the synthetic scene in place for all attitudes will give the pilot better situational awareness cues, either preventing the upset in the first place or helping to speed the recovery.

Dallas Duel

Backyard becomes key battleground for Southwest and American

Adrian Schofield Dallas

The Dallas market has become one of the most dynamic in the U.S. airline sector, as two industry heavyweights focus their growth ambitions on the North Texas metroplex. While Southwest Airlines is dramatically ramping up domestic flights from Dallas, American Airlines is increasingly relying on it as an international gateway.

The world's largest full-service airline (American) and biggest low-cost carrier (Southwest) are both headquarted in this area. Rivalry over their hometown market has been somewhat limited as they each dominate a different local airport, but the recent loosening of restrictions on Southwest's Love Field hub has escalated their domestic competition. Meanwhile, American faces other challengers as it launches new international flights from Dallas/Fort Worth International Airport (DFW).

Southwest's moves have been prompted by the phase-out of the Wright Amendment, a piece of legislation that severely limited the range of nonstop flights out of Love Field. This has allowed it to introduce a raft of new long-haul domestic services, often directly competing with the much larger American domestic operation at DFW.

The additional Love Field flights have been launched in phases since October. The third tranche was introduced April 8, boosting Southwest's daily departure total at the airport to 166 from 153. A fourth phase will lift the total to 180 on Aug. 9—marking a dramatic increase from the 118 daily departures before the expansion began.

Demand for these routes has been strong. Southwest is achieving load factors of 80-90% on its new flights from Love Field, which is higher than its system average, says Andrew Watterson, the carrier's senior vice president for network and revenue management. "So far [the expansion] is exceeding our expectations" in terms of customer demand, he says.

The earlier phases included new routes to Southwest's other focus cities, typically with multiple daily frequencies. The last two phases are mainly aimed at broadening the network, with just one or two daily flights to a wider range of destinations.

A few of the new routes with multiple frequencies have been "tweaked" after their introduction, with flights either added or subtracted from these markets to calibrate demand, says Watterson. For example, routes to Denver International and Chicago Midway International airports were bumped up, and flights to Ronald Reagan Washington National Airport were trimmed slightly.

Some existing flights to short-haul destinations were also cut because they had been primarily used as stopping points to comply with Wright Amendment restrictions.

The flood of new capacity from Southwest has had a profound effect on the broader Dallas market. American executives say fares and revenue have dropped thanks to increased competition on many long-haul routes. However, they note that the lower fares are also stimulating new traffic, so American does not plan to trim its own capacity in Dallas despite the declining yields.

American has known about Southwest's Dallas growth intentions for some time and was fairly accurate in its predictions of where the new service would go, says Charles Schubert, American's vice president of network planning. "The repeal of the Wright Amendment didn't sneak up on us," he says.

Southwest is still somewhat limited in its ability to take on American in Dallas, as a few key restrictions remain at Love Field despite the Wright Amendment's removal. The airport is capped at 20 gates—of which Southwest leases 18—and no international flights are allowed.

Schubert notes that this gives American an advantage in Dallas. The carrier can connect customers to international flights at DFW, and it offers more frequency in key domestic markets. Because American has a greater range of aircraft sizes in its fleet, it can also viably serve smaller markets than Southwest.

The size of the Love Field operation and its fleet profile will "somewhat dictate the network [Southwest] can serve" from Dallas, says Schubert. But he emphasizes that Southwest is "a very fierce competitor . . . and we expect to compete just as vigorously for traffic" in Dallas.

DFW CEO Sean Donohue admits that some passengers who typically fly from DFW are trying the new Southwest flights instead. However, he says the overall effect of Southwest's network expansion on DFW has been "minimal." Detailed estimates of the traffic loss will be compiled after

Southwest is putting more Boeing 737-800s on its Dallas routes as it increases long-haul flying from Love Field.

TONY STORCK/AIRLINERSGALLERY.COM

JOE WALKER

American will open its first Boeing 787 base at Dallas/Fort Worth International Airport.

Southwest's final wave of new flights is introduced in August.

Another blow to DFW traffic occurred when low-cost carrier Virgin America moved its Dallas operation from DFW to Love Field in the wake of the Wright Amendment changes. The carrier operates five routes from its two gates at Love Field.

Despite these factors, Donohue still expects DFW to set a new passenger record in 2015. Any traffic losses will be more than offset by gains from increased international services and American's initiative to increase flight-banking at the airport—which is expected to boost connecting traffic.

The growth of international traffic at DFW in recent years has been partly driven by American's introduction of new Asian routes from the airport. Flights to Beijing are due to begin May 7, Hong Kong and Shanghai services were added last year and a flight to Seoul was introduced in 2013.

American has been making a big push into Asia, a region where it has previously lagged some of its major competitors, Schubert says. Focusing this growth on the airline's largest hub at DFW makes sense since it offers strong connections to the rest of American's network, both domestic and in Latin America. This gives new Asian markets the greatest chance of success.

However, further growth in Asia from DFW does not appear to be on the agenda for American, at least in the short term. Schubert notes that the carrier has now covered five of the major Asian business markets with routes from its main hub, and while other opportunities exist from DFW, they would be a tougher proposition.

American is also making DFW the initial base for its new Boeing 787 fleet. The airline is due to launch 787 service on its Dallas-Chicago route on May 7, before introducing the type on its routes from Dallas to Beijing and Buenos Aires on June 2 and 4, respectively. The new aircraft are scheduled to take over the DFW-Shanghai route on June 26.

The carrier expects to have four 787s in service by the time international operations begin in June. The three long-haul routes are being flown by 777-200ERs until the 787s take them over.

American estimates it will take delivery of 13 787s this year, out of its total order of 42. While DFW will be the early focus, the carrier will also introduce 787s on routes from other U.S. hubs this year.

As well as the competitive threat from Love Field, American is facing challenges at DFW itself. This has been particularly true in the international arena, as more full-service and low-cost carriers have established service to the airport.

This trend is set to continue. DFW is in discussion with a number of international airlines, and by the end of this year up to two are likely to confirm they will fly to Dallas, Donohue says.

The airport is particularly focused on North Asia and Europe as areas of growth for international services, Donohue says. DFW currently has five nonstop routes to Europe, and now is attempting to "get into some of the [European] secondary markets that have seen a lot of growth out of [U.S.] East Coast hubs."

DFW views itself as a natural connecting point for traffic flows from North Asia to Latin America, says Donohue. He notes that American has an extensive Latin American network from its DFW hub, and there is a good opportunity to entice airlines to add more Asian service.

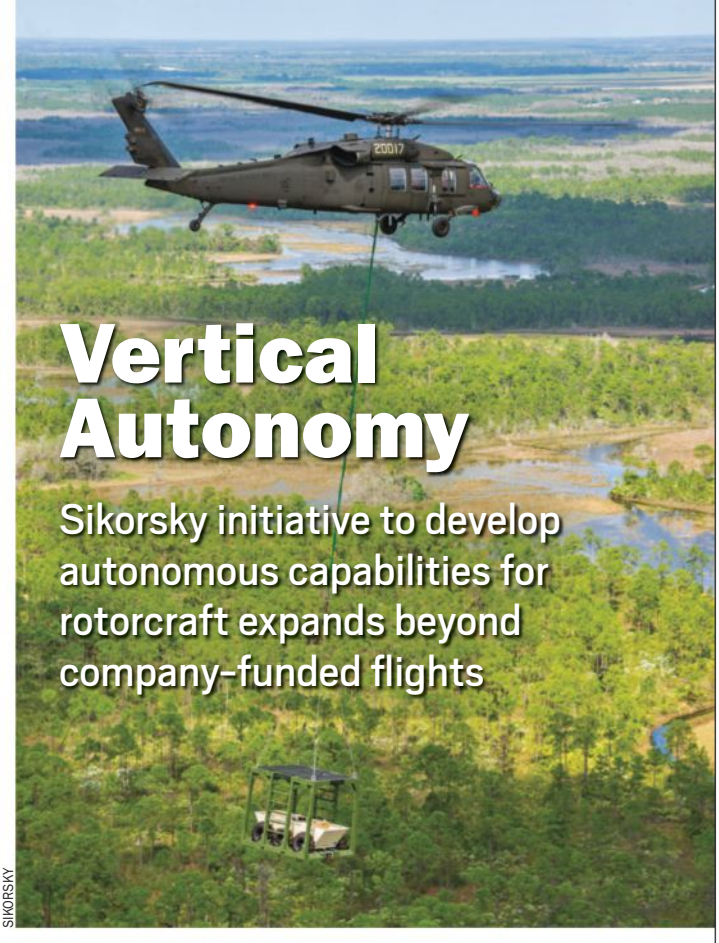
The international expansion has been a priority for DFW, offering better growth prospects than the tight U.S. domestic market. Over the past four years the airport has gained 20 new international destinations and nine more international carriers. It became one of a handful of U.S. airports served by all three of the major Gulf carriers, after Etihad and Qatar Airways introduced DFW flights in 2014.

Last year Qantas Airways and Emirates put Airbus A380s on their existing routes to DFW within days of each other, the airport's first service with that type. Donohue says British Airways appears to be the most likely candidate to add further A380 service at some point, as it has significant capacity on the London Heathrow-DFW route in conjunction with its partner American.

Another significant development is the rise of international low-cost operations at DFW. Mexican LCC VivaAerobus launched flights to Dallas in March, and its rival Volaris inaugurated service there on April 29. Spirit Airlines also offers Mexico flights from the airport.

While Spirit has surprised many by becoming the second-largest carrier at DFW, American dominates the hub by a wide margin. Donohue says there is scope for American to expand further at DFW and even build it into a hub on the scale of Delta Air Lines' Atlanta operation. "We'd love to create a proposition where American wants to grow [more at DFW]," he says.

Digital Extra *Read more about DFW's terminal refurbishment projects at* **AviationWeek.com/Dallas**



SIKORSKY

Vertical Autonomy

Sikorsky initiative to develop autonomous capabilities for rotorcraft expands beyond company-funded flights

A UH-60MU conducts aerodynamic testing of UGV in its "kennel" ahead of the collaborative demo.

Graham Warwick Washington

Sikorsky's initiative to develop certifiable autonomy technology for rotorcraft is gathering momentum, with three helicopters to be flown in demonstrations funded by Darpa, the U.S. Army and the company itself.

In 2014, the Sikorsky Autonomy Research Aircraft (SARA), a modified S-76 commercial helicopter, completed autonomous obstacle avoidance and landing-site selection demonstrations. This year, the aircraft will fly for a Darpa program to add automation to existing fixed- and rotary-wing aircraft and reduce onboard crew.

Developed under the company-funded Matrix Technology program, the autonomous mission manager (AMM) flying in SARA will also be used in an Army-funded program to demonstrate collaboration between unmanned ground and air vehicles using a Sikorsky UH-60MU Black Hawk.

A development of the same autonomy system will be used in an optionally piloted Black Hawk demonstrator Sikorsky is building with its own funds to show the Army how surplus UH-60As could be modified to move cargo for the same $5-per-ton-mile cost as 5-ton trucks.

Equipped with the baseline autonomous mission manager and a perception system comprising scanning lidar and cameras operating in two different spectra, SARA in 2014 showed it could autonomously select a landing site and touch down safely, says Igor Cherepinsky, chief engineer for autonomy.

"We gave the vehicle high-level mission goals: points to fly toward and a 'land near' point somewhere in the landing zone," he says. "SARA executed the plan, and when it got near it selected several landing sites, ranked them in priority and presented its choice to the ground station."

Several scenarios were demonstrated, including the operator waving off the landing, changing the site selection and doing nothing. "If the operator did not intervene, the aircraft landed itself," he says, adding that safety pilots were onboard the helicopter but did not touch the controls.

Subsequently, Sikorsky has integrated satellite communications for beyond-line-of-sight control and made updates to the perception system to improve filtering based on lessons learned, Cherepinsky says. More company-funded demos are planned.

The next flights will be conducted under Sikorsky's $8 million contract for Phase 1 of Darpa's Aircrew Labor In-Cockpit Automation System (Alias) program. "Darpa's and our visions of autonomy as assistance to the human really align," he says. "We want to add more assistive capabilities to the aircraft and let the pilot decide how much to use."

Alias aims to develop a platform-agnostic robotic kit that can be installed in existing aircraft to automate cockpit functions and reduce onboard crew, then be removed and moved between aircraft types—fixed- and rotary-wing—with the system autonomously acquiring the knowledge to fly each different aircraft.

In Phase 1 of the program, for which Darpa also awarded contracts to Aurora Flight Sciences and Lockheed Martin, Sikorsky is looking at the human-machine interface (HMI). "We have designed some unique ways for the pilot to interface with the system," says Cherepinsky, adding that the HMI and some of the knowledge-processing technology will fly on SARA "in a few months."

Separately, a fly-by-wire UH-60MU bailed back from the Army is being prepared for a demonstration with Carnegie Mellon University to show that an autonomous helicopter and unmanned ground vehicle (UGV) can work together to survey a contaminated site.

The unmanned helicopter will carry Carnegie Mellon's Land Tamer UGV in a cage or kennel, autonomously find a landing site, lower the vehicle to the ground, release it and return to base. The UGV will then traverse the site using onboard sensors to survey for contamination. Both platforms will operate beyond line of sight.

The Black Hawk was modified for optionally piloted operation under the Manned/Unmanned Aerial Lifter (Mural) program, a cooperative effort with the Army to conduct an unmanned cargo logistics demonstration. That demo was completed in April 2014, and the helicopter has been upgraded with the latest version of the autonomous mission manager.

"We have done several flights with the UGV being carried by Mural," says Cherepinksy. "We are in final integration of the AMM changes necessary to run the mission. We will start flying the UGV and UAV together in a few weeks. The full demo will be at the end of the summer."

The optionally piloted Black Hawk program, meanwhile, completed its preliminary design review in March. "We are starting to modify the aircraft," he says, referring to a retired UH-60A acquired from the Army. "Critical design review is later this year, and we will fly some time in 2016."

Autonomous mission manager hardware has been productionized for the optionally piloted Black Hawk, while software from the SARA testbed will go through safety-of-flight testing and Black Hawk-specific modules will be added based on the outcome of the Mural demonstration.

Pilot Woes

North American regional airlines fear pilot shortage

CAPE AIR

After starting with Cape Air as interns, many become captains and move on to JetBlue Airways.

Brian Sumers Los Angeles

To preview an annual gathering of the North American regional airline community, the Regional Airline Association (RAA) asked top executives at 15 carriers to name the three most pressing issues facing the industry. All but three cited a possible pilot shortage, which remains one of their most vexing problems.

"The continued flow of future aviators—both pilots and mechanics—is a big focus for RAA," says Kelly Murphy, the group's spokeswoman. But there likely will not be any panaceas at the RAA's Convention May 11-14 in Cleveland. By now, regional airlines know how to cope, with many taking a two-pronged approach. One is to be more aggressive in recruiting and paying pilots. The second is to work with legacy carriers to make sure they have reasonable expectations about the schedules the regionals can fly.

Major airlines are also aware of this problem. United Airlines, for example, told analysts in April that it was drawing down its 50-seat fleet in part because its partners were having difficulty staffing the jets. "The reduction in availability of pilots for smaller airplanes is clearly affecting us, as it's affecting all of our competitors," United CEO Jeff Smisek said.

On an April 30 earnings call, SkyWest Airlines President Chip Childs said his carrier is "fortunate" to have enough pilots for its 2015 plan. But SkyWest is also shrinking slightly, going from a total fleet of 717 aircraft at the end of 2014, to 693 at the end of the first quarter. By year-end, it will have 633 aircraft.

"It's not as easy as it has been in the past," Childs said. "We fundamentally believe that with an issue as big as this pilot shortage you have to be very proactive and plan with the partners so we can make sure we can deliver what the partners want to deliver to their customers."

SkyWest is generally in good shape—the carrier was named one of "America's Best Employers" by *Forbes* earlier in April—but attracting qualified pilots is a problem elsewhere.

Pay remains a major issue, and while it has improved—many carriers offer lucrative signing bonuses—it is not yet high enough across the board to alleviate concerns. Airlines also continue to complain about the FAA's rules requiring 1,500 flight hours and an Airline Transport Pilot certificate for most new first officers.

In his pre-conference note to the RAA, PSA Airlines President Dion Flannery blames the new rules for resulting "in a multitude of unintended consequences throughout the industry." He calls on regional carriers to lobby for changes to make it easier for smaller airlines to attract pilots. In his note, Horizon Air President David Campbell states that "other challenges pale in comparison" to the pilot problem.

At the conference, industry leaders will hear from Kent Lovelace, a professor in the University of North Dakota's Department of Aviation. Lovelace tells Aviation Week the industry is on the right track with pay but says his research suggests prospective first officers are less concerned about compensation than airline executives might expect. "We did one qualitative study, and all but one of the students said they wanted a salary that is comparable to another college graduate," Lovelace says. "If a social worker is making $38,000 or a nurse is making $42,000, students want to earn that much. They are not asking for the Moon."

But Lovelace says some regional carriers may underestimate how much lifestyle factors affect whether a prospective pilot chooses an airline job or a corporate one. He says many ask themselves, "Where will I be based?" before making that decision.

"In my generation, you did whatever you needed to do to get the job you wanted," Lovelace says. "That attitude doesn't exist now. They are more concerned about friends and family."

Regional airline executives can't always base pilots in desirable places, but Lovelace recommends trying low-risk strategies to improve morale. He credits one airline for giving pilots four free hotel room nights per month at their base, so pilots living elsewhere won't have to rent a crash pad. Lovelace also suggests regional carriers work with major airlines to set pilot schedules to accommodate work/life balance. "There's no short-term fix," he says.

Some carriers are already moving in that direction. When Republic Airways told pilots in April that Delta Air Lines had extended a contract for 38 Embraer ERJ 145s until 2021, five years beyond what was initially planned, Republic promised pilots their work days would improve. In the note, executives underscored that Republic wants to be an "industry leader" in quality of life.

Other approaches work, too. Young pilots look for favorable flow-through agreements that improve their chances of working at a major carrier. Pilots also appreciate bonuses—Endeavor Air offers up to $80,000 in retention bonuses for a long-term commitment—as well as financial support for their loans.

Formal programs are another option. The most effective one, Lovelace says, is JetBlue's agreement with Cape Air called the University Gateway program. Students at six preferred universities (including North Dakota) start as college interns at Cape Air or JetBlue, then fly for at least one year as flight instructors before joining Cape Air for 2-3 years. Afterward, pilots are given preferred interview slots with JetBlue.

Cape Air President Linda Markham says 20 program graduates have moved on to JetBlue. More than 100 more are in the pipeline. "It helps to have the carrot at the end of the stick," Lovelace says.

Cool View

Technology leap for regional jets as E2 cockpit receives transformational upgrades

John Croft Washington

Embraer's modernized E2, the updated version of the venerable E-Jet family, will be the first factory-built commercial jetliner to begin bridging one particular technology gap between business jets and transports when deliveries of the twinjet begin in 2018. Chief among the new tools available to regional pilots, many of whom are relatively new to commercial aviation, will be synthetic vision—a 3-D representation of terrain, obstacles and runway—combined with certain energy-state awareness cues that have been available in modern business jet cockpits for nearly a decade. The information will be shown on 14.1-in. screens in landscape layout, four of which span the instrument panel, as opposed to the five 12.8-in. portrait-format screens on legacy E-Jets.

Honeywell's synthetic vision system will be standard equipment on Embraer's E2 jets, making the new regional aircraft the first in the airline sector to be delivered with the safety aid.

Known as SmartView in Honeywell parlance, synthetic vision is now a mainstay in new business jets as well as in lighter aircraft and even on tablets and iPads. While pilots can use the information for "situational awareness" only (and not for navigation), the safety benefits are tangible, including a sense of attitude based on terrain and the energy-state awareness cues—flightpath vector, acceleration indicator, speed error tape and descent angle indicator—that have historically been available only in head-up displays. As in the current generation of E-Jets, Embraer will offer single or dual head-up displays in the E2, potentially with synthetic-vision capability.

The E2 will also have a companion virtual vision system for ground operations—Honeywell's 2-D and 3-D airport moving map applications on the primary flight display (PFD). The 3-D moving map shows an exocentric view of the aircraft, from behind and to the right and includes taxiways and runways with labels and other identification information including "hot spots," which are areas the FAA has found that increase runway incursion risks. There's also a "wall" or roadblock that pops up when the aircraft is approaching the hold-short line of a runway intersection from a taxiway. When preparing for takeoff, the pilot can switch back to the normal 3-D view on the PFD, or the system will automatically switch when power is applied. On landing, the PFD smoothly transitions from normal view to exocentric at 50-kt. airspeed.

Honeywell has also developed a taxi helper to compute the best path to a runway end, including constraints, and plot the path on the 2-D airport map. The E2 will also come with automatic dependent surveillance-broadcast (ADS-B) "in" avionics, meaning the aircraft will receive position and ID information from nearby aircraft and equipped vehicles, data that can be used for real-time traffic updates around the airport.

Marc Herdegen, director of marketing and product management for synthetic vision and enhanced ground proximity warning systems, says customer polling has revealed some "particular needs" of the regionals, including that pilots are often fairly new in the business. "We're trying to incorporate situational awareness tools that help them operate more safely and efficiently," says Herdegen. "Synthetic vision helps with that." He notes that SmartLanding and SmartRunway applications, also onboard the E2, are equally helpful. SmartRunway is a software package that includes Honeywell's runway awareness and advisory system (RAAS). The RAAS sends alerts when an aircraft is taking off or landing on a taxiway or a runway that is too short. SmartLanding had airborne and ground modes, with the ground mode including runway distance remaining callouts. The airborne mode has a stabilized approach monitor (SAM) and long-landing monitor. SAM tracks specific stabilized approach criteria—landing gear down, landing flaps set, on glideslope, speed within limits, vertical speed less than 1,000 fpm—and automatically issues advisories if pre-set criteria are not met.

EMBRAER

The E2 will also have Honeywell's next-generation Flight Management System (FMS), an upgrade that will be coming to the existing E-Jet fleet—of which more than 1,100 have been delivered—in the near future. Key features of the FMS, which first flew on the Boeing 747-8 and is on the Gulfstream G650 business jet, include a cost index and a capability for optimized profile descent (idling) as well as datalink messages that can be automatically entered into the FMS rather than input by hand, including route changes. The cost index is the ratio of time-related costs in terms of crew salaries and aircraft maintenance to fuel burned; it is used to optimize cruise altitudes and power settings.

Despite being the first air transport aircraft to be certified with synthetic vision on the PFD, Honeywell does not expect any major roadblocks along the way to entry-into-service.

Delayed Recovery

PILATUS

Business aviation in Europe, in the doldrums for years, now sees signs of resurgence

Heinrich Grossbongardt Hamburg

Six years after the business aviation sector suffered from the ripple effects of the sub-prime mortgage crisis, the industry in Europe has still not fully recovered. Following a strong bounce back to near-pre-crisis levels, the number of departures has been in a steady decline. Since 2011, top business aviation airports in Geneva, Zurich and at Paris-Le Bourget have lost 5-10% of their executive jet traffic.

After a promising start in 2014, charter operators have been severely affected by the conflict between Russia and Ukraine. According to Eurocontrol figures reported by the European Business Aviation Association (EBAA), the number of daily flights in Ukraine is 71.6% lower than a year ago.

Economic sanctions imposed on Russia have taken a toll on the elite in that country, who had been a key customer group for Western European providers. Because of the weak ruble, flights are now 50% more expensive. So jaunts to Paris, Munich or Berlin and luxury trips to the Cote d'Azur have become less affordable and therefore less frequent. Traffic between Russia and Germany is down by one-third, and the number of business jet flights between Russia and France is 26% lower on a year-to-year basis. "The effect can be noticed across Europe, because Russian-owned business jets are often registered in Europe and operated under a European air operator certificate (AOC)," notes Tobias Lagergren, data analyst at Avinode.

Mid-size and super-midsize jets like the Citation XLS, Challenger 300 and Legacy 600, popular in these markets, have been hardest hit. While EBAA reported 0.7% more flights in 2014—the first signs of growth since 2011—it is safe to assume that revenues have shrunk again; there are no official statistics.

One reason many operators are struggling is that the fleet has been growing at an annual rate of 4-7%. Assets are heavily underutilized. EBAA/Eurocontol data indicate the number of flights per aircraft has declined from 42 to just 26 per year since 2008. This, however, includes corporate aircraft.

Another pressing problem is the high number of gray-market charter flights, which are run by aircraft owners/operators who offer illicit flights without any authorization. According to the EBAA, 14% of all movements in Europe are illegal. The practice is rife in Russia, Ukraine and Eastern European growth markets as well as in soft regime countries like Belarus. But it is a significant problem in Germany, France and the U.K. as well.

The overall situation is still pretty dire, says Bernhard Fragner, CEO of Linz, Austria-based Globe Air, which operates a fleet of 12 Citation Mustang very light jets. "However, March and April have been surprisingly good." EBAA figures and other sources confirm the positive trend. In key markets like France, Spain and the U.K., demand is clearly up. "We see Italy coming back as well," says Fragner. On the other hand, traffic in Germany is still down, despite the strong economy.

One harbinger of hope is that new customers are finally discovering business aviation. "We are seeing more and more requests from former airline customers," says Fragner. As European mainline airlines fight for profitability, there is a clear trend toward bigger aircraft and fewer frequencies on regional routes. So companies without easy access to a major airport are realizing that an increasingly high portion of their business travel can't be done as a day trip. Fragner notes, "We are able to convince more of those customers that the higher price of a charter jet makes good business sense."

Pilatus says the PC-24 will be the only business jet able to operate from unpaved air strips.

The upside of this difficult economic environment is that it has sparked consolidation in the highly fragmented industry. In 2013 just 2.1% of all 427 operators in Europe had a fleet of more than 20 aircraft; 80.2% had 2-5 aircraft. Luxaviation is one of the companies actively driving consolidation. After having received its own AOC in 2009, the company has since acquired operators in France, Germany, Portugal and the U.K., bringing together a fleet of close to 100 jets, which creates a significant potential for lowering costs through economies of scale.

While charter operators in Europe are struggling, manufacturers are doing exceptionally well. On Feb. 6, Dassault celebrated the first flight of its new long-range Falcon 8X. The tri-jet—an offshoot of the successful 7X—is planned to enter service in the second half of 2016. Dassault initially plans to build the aircraft, which is priced at about $60 million, at a rate of three per month. The smaller Falcon 5X is expected to take to the air soon.

Swiss Pilatus, too, is enjoying an upswing. Last year it delivered 66 of its single-engine PC-12. When the niche specialist introduced its versatile PC-24 jet at Ebace 2014, the company was able to announce 84 orders within just two days. Production is sold out until 2019.

Blurred Vision

Uncertainty dogs next-generation synthetic vision systems

John Croft Paris

The evolution of synthetic vision from pretty picture to tactical, practical tool for keeping schedules and boosting capacity is in a holding pattern, as regulators and the business aviation sector come to grips with the benefits versus the costs of having the capability.

Decisions by the likes of Bombardier, Dassault, Embraer and Gulfstream to proceed or mothball Synthetic Vision Guidance System (SVGS) technology could come later this year when the FAA completes and publishes guidance and policy on the equipment, and on performance, operations and certification of the system, information likely to be echoed by European regulators. That guidance will largely follow specifications crafted by the government and industry RTCA Special Committee 213 (SC213), although the FAA could make key changes that could alter the cost-benefit equation and give OEMs reason to scrap plans to deploy SVGS in the near term. SC213 develops minimum system performance and operational performance specifications for enhanced flight vision systems and synthetic vision systems, products that typically are adopted by the FAA and other regulators. An earlier version of SVGS guidance that SC213 sent to the FAA in 2011 was rejected, in part because industry had not yet tried out the technology in demonstration projects.

SVGS uses the basic elements of synthetic vision—a 3-D representation of terrain, obstacles and runways, combined with advanced guidance cues including a flight path vector, flight path angle and depiction of the runway—but adds multiple levels of verification to ensure that a runway and the approach to it are in the proper place, making SVGS a source for navigation information. Legacy synthetic vision systems were first approved by the FAA in 2006 as "situational awareness" tools for the primary flight display but were not considered usable for navigation.

With those assurances, a pilot using SVGS on a head-down or head-up display would be able to fly to the actual runway using a virtual depiction on the primary flight display or head-up display. The system would also provide "credit" in terms of lower approach minimums for Cat. 1 (Cat. 1) instrument approaches and GPS-based localizer performance with vertical guidance (LPV) approaches. The initial guidance will allow for a 150 ft. decision height

HONEYWELL

This screen shot from a Honeywell flight test shows the SVGS view on the primary flight display of the landing environment just below the proposed 150-ft. decision height.

(the point at which the crew must either have visual confirmation of the runway environment or perform a missed approach) with visibility as low as 1,400 ft. runway visual range (RVR), compared to the usual 200 ft. and 1,800-2,400 ft. minimums, respectively, for the two types of approaches. Minimums below 200 ft. generally require more airport infrastructure, including runway centerline lighting, and other safety equipment, elements that would be waived for the SVGS approaches.

The lower minimums are expected to provide more reliable access to thousands of runway ends that would otherwise require costly Cat. 2 or 3 instrument approach equipment, trained crews on board and more equipment on the ground. The FAA operates a total of 1,277 Cat. 1 ILS approaches at U.S. airports. Operators with head-up displays and specialized training can already get "special authorization" (SA) approvals to fly down to 150 ft. decision height minimums on 109 Cat. 1 and 29 Cat. 2 approaches in the U.S., but SVGS advocates are looking for much broader access. With SVGS, ideally that extra 50 ft. would be available to any aircraft with SVGS, whether head-up or head-down, at all 1,277 Cat. 1s as well as for the 914 LPV approaches that have a 200 ft. decision height (the FAA has a total of 3,534 LPVs, most with higher minimums).

Speaking at an SC213 meeting in Paris in mid-April, FAA representatives made clear that the agency would need to see adequate demand from the user community before committing the resources and manpower to make the necessary changes that would allow for SVGS across all Cat. 1 and LPV approaches.

"Our management is looking for a business case," said an FAA representative at the meeting. "If we do this, what would be the cumulative effect on the [National Airspace] System? What would the benefit to the NAS be before they divvy up resources to address this task?"

The FAA explains that since the processes and charting for special authorization for Cat. 1 approaches (SA Cat. 1) at airports already exist, the impact on the agency to deploy more approaches for those runways would be relatively minor, assuming airport operators make a request for the approaches.

For LPV, however, there are currently no charts or other processes in place to allow for lower minimum approaches. "The whole gamut of building an approach and charts—that's a pretty large endeavor that is expensive and resource-intensive," said the FAA representative. "So before the FAA would entertain getting behind that, in the near term, I think they would like to know if there's an interest out there. If there are just a handful of operators who would do that, then it might not be a good cost-benefit. It might not really expand the capacity in the NAS. If there's a lot of interest, and folks speak up and say we really want to do this, and can produce numbers and a business case and demonstrate that the taxpayer will benefit, then I think there will be more interest at the FAA headquarters level."

With SVGS technology issues well in hand at their avionics providers—largely Honeywell and Rockwell Collins—business aircraft OEMs are now querying the sector for the level of interest. Honeywell says it is "too early" to announce an SVGS certification time frame, but says it has "strong interest" from several OEMs, particularly in the business aviation and regional jet market, with the commercial airline sector also showing "high" interest. "Although [airlines] have not yet equipped with synthetic vision systems (SVS), they view operational credit as a potential incentive to help their operators equip with the SVS safety technology," says Honeywell. The company has already finished its SVGS testing campaign and transitioned the technology from its research team to its product group.

In 2013 Honeywell had applied for an FAA and European supplemental type certificate (STC) for SVGS as part of the EASy avionics suite in the Dassault Falcon 900, but only to allow the company to undertake a proof-of-concept test to demonstrate SVGS to OEM pilots and regulators. Honeywell has since abandoned the application for a standalone STC and is instead planning to certify SVGS as part of a broader software upgrade for its Primus Epic integrated cockpits at some point in the future.

The proof-of-concept phase involved flight testing in a Honeywell Falcon 900EX in May 2013 with nine pilots flying 64 approaches, primarily focusing on the behavior of five approach path monitors that Honeywell developed to ensure SVGS performance during an approach. The following month, 12 pilots tested the SVGS in simulated instrument weather conditions in a Boeing 777 "M-Cab" engineering simulator in Seattle, focusing on the transition from SVGS on a head-down display to the outside visual environment at various decision heights and visibility conditions. Data collection included flight technical error (FTE), which showed that pilots had no problem with the head-down to head-up transition and landing, says Thea Feyereisen, Honeywell Aerospace Engineering Fellow.

Specific to Honeywell's approach to SVGS is a head-down display of the information, with a track-centered (versus heading-centered) synthetic vision display. The track-centered display results in a smooth presentation of the scene, particularly in turbulence. The company uses a "crabby symbol" cue to show the pilot the orientation of the runway with respect to the nose.

Rockwell Collins, which builds head-up guidance systems that can also display synthetic vision, is developing SVGS for the head-up display (as well as for the primary flight display), using a heading-centered synthetic scene. Bombardier is interested in certifying the company's SVGS for the Global Express line of aircraft, although a flight-testing program is on hold at the moment while the airframer waits for the FAA guidance, company approvals and the latest SVGS software update from Rockwell Collins, provider of the Pro Line Fusion integrated Global Vision flight deck for the Global Express family.

ROCKWELL COLLINS

Rockwell Collins's SVGS on the head-up display reveals the airport under a virtual dome, with an extended runway centerline marker, runway border highlights and terrain.

The Global Vision system, which has been delivered on about 300 aircraft, features synthetic vision on the head-up display, allowing authorized operators to descend to the 150 ft. decision height at SA Cat. 1 airports. Bombardier wants an SVGS that will be usable at all Cat. 1 runways, although it has not set a target date for the offering. The company last year demonstrated its version of SVGS to the FAA and others in a simulator, and is currently performing marketing surveys to find out how much demand there is for SVGS. Pending software delivery and company approval, officials plan to begin flight testing SVGS on a Global 5000 flight-test aircraft in 2016. A year ago, Rockwell Collins said it had expected to certify SVGS for Bombardier by September this year, a target that has now been pushed back.

One of the problems with marketing SVGS to the business aviation sector is that the technology is probably most useful not as a means to an end for lower minimums, but as one element of a combined vision system (CVS). CVS fuses several vision inputs depending on the phase of flight: Pilots would use SVGS to get an aircraft down to 150-100 ft. decision height minimums and a 1,400-1,000 ft. RVR, respectively, at which point they would use an approved enhanced flight vision system (EFVS), with infrared, millimeter-wave radar or other technologies showing the scene on a head-up display, as a substitute for natural vision to fly down to the runway and taxi to the parking spot.

With EFVS today, operators can get approach credit to descend to a 100 ft. decision height on a Cat. 1 runway, although the FAA is preparing final rules that will allow additional credit depending in part on the performance of the equipment. Companies continue to research CVS, but have not yet moved the capability into the product marketing arena.

Bombardier says the promise of CVS as the ultimate vision product makes SVGS by itself difficult sell to customers in the interim, and could force the company to offer the capability at no charge in return for operator feedback and lessons learned on the path to developing and deploying a CVS.

"We see SVGS as a step to CVS," says one Bombardier engineer close to the development but not approved to speak on the company's behalf. "What we're all after is CVS."

CVS as an end state is problematic for Honeywell, however, as its prototype is head-down on the primary flight display and as such does not meet the EFVS rules. Feyereisen says the company is trying to figure out "how to break through the HUD limitation" in the rules, including discussions with the FAA on certain hybrid modes that could allow the pilot-monitoring in a single-HUD aircraft to use CVS to better monitor an approach.

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One Focus

Offering customers a choice is behind bringing Eclipse and Kestrel together under One Aviation

Graham Warwick Washington

Work on building conforming prototypes of the Kestrel K-350 has yet to begin.

ONE AVIATION

Offering a family and not just a single aircraft is usually the better business model and, by combining two one-product companies, newly formed One Aviation is hoping for success by providing customers a choice between two quite different types.

One Aviation is a holding company that will bring together Eclipse Aerospace with its EA500 twin-engine very light jet and Kestrel Aircraft with its K350 single-engine turboprop. The new company hopes to boost sales of the Eclipse so it can accelerate development of the Kestrel, which has been hindered by a lack of funds.

Principal players in One Aviation are Chairman Mason Holland and CEO Alan Klapmeier. Software-services entrepreneur Holland led the rescue of Eclipse from bankruptcy in 2009, re-established support, completed development and fielded upgrades for the EA500, and in 2013 restarted production of the improved EA550. Klapmeier formed Kestrel in 2010 after leaving Cirrus Aircraft, the successful light-aircraft manufacturer he founded with brother Dale Klapmeier.

Creation of One Aviation is not a merger. Instead, the shareholders in Eclipse and Kestrel are being asked to join a new holding company, a process not yet complete, Klapmeier says. Both companies have complicated debt structures, which will remain intact and independent, including agreements Kestrel has for state and local financial incentives in Maine and Wisconsin.

Kestrel's headquarters will remain in Superior, Wisconsin, to meet contractual obligations, he says, with an engineering operation in Brunswick, Maine. There are no plans to manufacture the all-composite K350 alongside the metal-airframe EA550 in Albuquerque, New Mexico, but a production site has not been selected, says Holland.

Klapmeier expects immediate cost efficiencies from bringing the companies together, in areas such as purchasing, information technology and the supply chain. "This makes it a stronger company. As long as we sell aircraft, structurally this all works and we stay in business," he says. And One Aviation's goal is to sell more aircraft by becoming more focused on the customer.

"Eclipse's management was focused on finishing the aircraft's development. They did not do a lot of stuff more focused on sales and the customer. The new management team has come in with a perspective on how we need to do things differently," says Klapmeier. "That is part of the One Aviation name: to be one company, with one message and one focus on the customer."

Half-jokingly, Klapmeier cites the Eclipse's lack of cupholders as an example. "They have focused on the big, hard stuff like anti-lock brakes. Unless you have flown without them, you will not understand how much anti-lock brakes change the way you fly the aircraft. But the customer cares about cupholders. And there [are] a bunch of things like that they were not focusing on."

"Job One" for One Aviation is to increase sales of the Eclipse from the 12 aircraft shipped in 2014 to 24-48 a year eventually. Increased cash flow from higher sales will help achieve certification and begin production of the Kestrel. But the new company will continue efforts to raise external investment to complete development of the turboprop single.

The creation of One Aviation "changes the financial picture in terms of raising money and completing the aircraft. For investors it takes away the concern that if we don't get all the money we will go out of business," says Klapmeier. "If we never raised any more money for the Kestrel, we would finish the aircraft off sales of the Eclipse. It would just take longer, so we will continue to raise more money."

Development of the Kestrel "is 90% done, 90% left to go," he jokes. "We are far along from a detail design and certification process point of view, but that does not begin to count the largest expense—building the conforming prototypes. Normally these things are done in parallel. It has taken us three years because unfortunately we are doing it in series [because of funding]."

The company is not taking orders for the Kestrel until there is more predictability, but already there is an uptick in interest, Klapmeier says. "Meaningful progress, when we feel secure enough to write big checks for the conforming prototypes, is still six months away." Reaction from the financial community has been generally positive, he says, adding "Even if I had all the money for Kestrel, I would still do this. It's the right long-term decision."

Both aircraft are priced at around $3 million, but Klapmeier says Eclipse and Kestrel are not competitors, but alternatives for the same customer. "Eclipse is the sports sedan; Kestrel is the Chevy Suburban. As we educate the customer on one, they may decide they need the other one," he says. Over time, One Aviation expects to add new products, perhaps through acquisitions, as well as derivatives. "The strategy works better with more."

—With William Garvey in Charleston, South Carolina

Marathon Moment

Cirrus closes in on personal-jet finish line after 10-year stretch

John Croft Washington

Four years ago, the future of Cirrus Aircraft's single-engine SF50 jet was in peril. The company had lost access to the Williams FJ33 turbofan powering its five-seater personal jet while U.S. officials determined whether the new owner, the Chinese Aviation Industry General Aircraft, could use the technology in that engine.

Today those troubles appear far behind as Cirrus prepares to certify its first jet—with the same Williams engine—and obtain a production certificate by year-end, delivering the second production-conforming aircraft to a customer in the same time frame and capping a decade of development work on the $1.95 million V-tailed composite design.

The first production-conforming aircraft, dubbed P1, is coming together at Cirrus's facilities in Duluth, Minnesota, where the pressure vessel built at the company's Grand Forks, North Dakota, plant, is being bonded to the tail and other components. Meanwhile, three conforming prototypes—C0, C1 and C2—are being flown in the FAA certification program and have accumulated more than 400 hr. of flight time. A fourth aircraft, a proof-of-concept model called V1, is also flyable.

Matthew Bergwall, the SF50 project manager, says C0 is being employed for the Part 23 Subpart B flight-testing regimen, which is 80% complete, while C1 is being used for natural ice testing, which is also almost complete. The company hopes to have flight-into-known-ice approval at the same time as certification. The aircraft has pneumatic deicing boots on the wing and V-tail "rudderator" leading edges. Anti-icing TKS fluid is distributed from the nose cone and a bar in front of the pilot's side windscreen.

C2 is being used for systems testing—including environmental and pressurization, and for other systems and options—says Bergwall. The test aircraft "conform" to the final design but are not production-conforming, as the models were not built on the production line. Engineers are finalizing performance numbers, says Bergwall, and "indications are that what we've shown has been accurate." That includes a jet fuel burn of 45-70 gal. per hour.

Bergwall says P1 will enter the program to help with reliability and functionality tests and for the FAA's flight standardization board demonstration flights. It will later be used for customer demonstrations. One of the early conforming aircraft will have a full interior, including modular seating and a "relief station" portable toilet that is available as an option "just in case of emergency," says Bergwall. "It's something people want." He says Williams is planning to certify the FJ33 engine this summer.

Production will ramp up slowly at first, achieving a throughput of 125 aircraft per year by 2017. The rate corresponds to over four years of backlog if the more than 500 position holders, 75% of whom own or at one time owned a Cirrus piston-powered aircraft, remain committed to the program. Two progressive payments are due: 10% 12 months before delivery and another 10% six months before delivery. "We'll be approaching some of our first customers pretty soon," explains Bergwall.

In parallel with the other work, the company is planning to certify the Cirrus airframe parachute system (CAPS) for the SF50 in May. The CAPS, which is standard equipment, is in the nose of the aircraft and designed to counterbalance the weight of the engine and cabin to provide a level descent for the 6,000-lb. maximum-gross-weight aircraft, nearly twice the 3,600-lb. MGW of the SR22.

Cirrus has not yet revealed all of the amenities for the cockpit, which will be based on the Garmin G3000 integrated flight deck. The panel features two 14-in. displays and other touchscreen interfaces that Cirrus will show this summer. It is designed to simplify operations as much as possible for owners who fly their own aircraft. Included is an automatic scheduling cabin pressurization system with internal monitors that will initiate an automatic descent mode if pressurization drops to certain levels; an automatic leveling function, called the "blue button" on the SR22; and electronic stabilization to help prevent the pilot from inadvertently putting the aircraft in unusual attitudes when hand-flying. Like the SR20 and SR22, the SF50 will have an option for an infrared-camera enhanced-vision system, but vendors have changed from Max-Viz for the SR line to Lexavia for the SF50.

Bergwall says Cirrus is developing a flexible training program "around the owner-pilot" but also will cater to professional pilots, with them receiving materials and training before delivery and full-motion simulators become available. Bergwall says upset-recovery training will not be included. He says there will be options for mentors to help new pilots gain experience.

As of now, the order book, at 550-plus aircraft, does not match what Bergwall says is a "tremendous" interest in the aircraft. He hopes that will change soon. "People are very excited and want to know more, but at the same time, there's a 'wait-and-see' attitude," he adds. "We'll get a true sense of the demand once deliveries start."

Cirrus plans to gain type and production certification for its new SF50 Vision single-engine personal jet before year-end, following a 10-year development program with starts and stops. Shown are the three conforming flight-test aircraft and a verifying prototype (far left).

CIRRUS AIRCRAFT

New Horizons

Piper nears 800 flight-test hours on advanced cabin-class turboprop

PIPER AIRCRAFT

A test Piper M600 takes off from the Vero Beach Municipal Airport in Florida.

Molly McMillin Vero Beach, Florida

When Piper Aircraft began working on the next evolution of its M500 Meridian, it focused on three goals—an increase in payload, range and speed. It is what dealers and customers had been asking for.

"With those three goals in mind, we set out to develop the M600," says Brandon McShea, program manager.

Piper formally announced the $2.825 million M600, a single-engine, 600-hp, cabin-class turboprop, on April 13, after months of striving to keep the project quiet. Three test aircraft are now flying. Certification and deliveries are expected in the fourth quarter of 2015.

"A little over three years ago, the advanced design team and the engineering group started out by laying out what would effectively be the new wing on the M600 product," McShea says.

They set performance targets of an 800-lb. payload with a 1,000-nm range.

The first aircraft took its maiden flight on May 13, 2014. The three test planes have amassed nearly 800 flight hours.

"The aircraft is flying and exceeding our expectations," says Drew McEwen, Piper's vice president of sales and marketing.

The M600 uses the same Pratt & Whitney PT6A-42A engine as the M500, but with an increase in horsepower.

The new aircraft has a maximum cruise speed of 260 kt. with a maximum range of 1,300 nm and a maximum payload of 1,200 lb. Descent speed, or VMO speed, has increased significantly from 188 kt. for the M500 to 250 kt. for the M600.

Although the company only recently began taking orders from dealers, Piper has more than a 12-month order backlog for the M600 today, McEwen says.

The advent of this model means Piper can enter new markets. "What this airplane is going to allow us to do that we haven't done is special missions, because of its range," McEwen says. "We are starting to have those discussions that we didn't have before."

With the M600's range and payload, Piper is also targeting the owner-flown market and corporate flight departments with dedicated pilots. "It gives us a business environment," McEwen says.

Piper builds the aircraft at its Florida facility. "We still do everything right here in Vero Beach," McEwen says. "We're fully integrated. We are a dying breed, but what we get out of it is, if we need to make changes, we just go out there and make changes. It is easy to control the process and the supply chain."

To meet the aircraft's performance goals, the company focused on the wing. The M500's wing is a derivative of the original 310 Malibu's, which evolved into the wing of the M350.

"That evolution was only able to take that product so far in terms of structure and fuel capacity," McShea says. "So when we looked at this product and what it needed to do, we knew we had to start with a clean sheet."

The M600's wing is larger and thicker at its root. It is a swept-wing design with a single fuel tank that is able to carry 90 gal. more fuel than the M500.

While the outside of the fuselage did not change, internally the change was extensive.

"The interior of the fuselage is significantly beefed up for the increase in loads," McShea says. "It required us to add parts, to add structure. That adds weight.'

The company has concentrated on reducing weight, drag and, subsequently, cost. That also led to manufacturing changes at the facility.

"We used a lot of modern manufacturing technologies as well as [other technologies] we've been using here for a long time—a lot of bonded structure in the wing and the fuselage. We were using quite a bit of machining, taking aluminum billet and machining it down to an optimized component within the wing." Chemical milling of the skins was also added.

Aesthetic considerations played a big part. "With a higher-class product, we wanted to offer a superior ownership experience," says David Athay, technical sales manager. "We went through the entire airplane."

The interior received visual and functional upgrades: details such as luxury seating, stylized side paneling and lighting, the addition of USB charging ports and new, more comfortable pilot armrests were added.

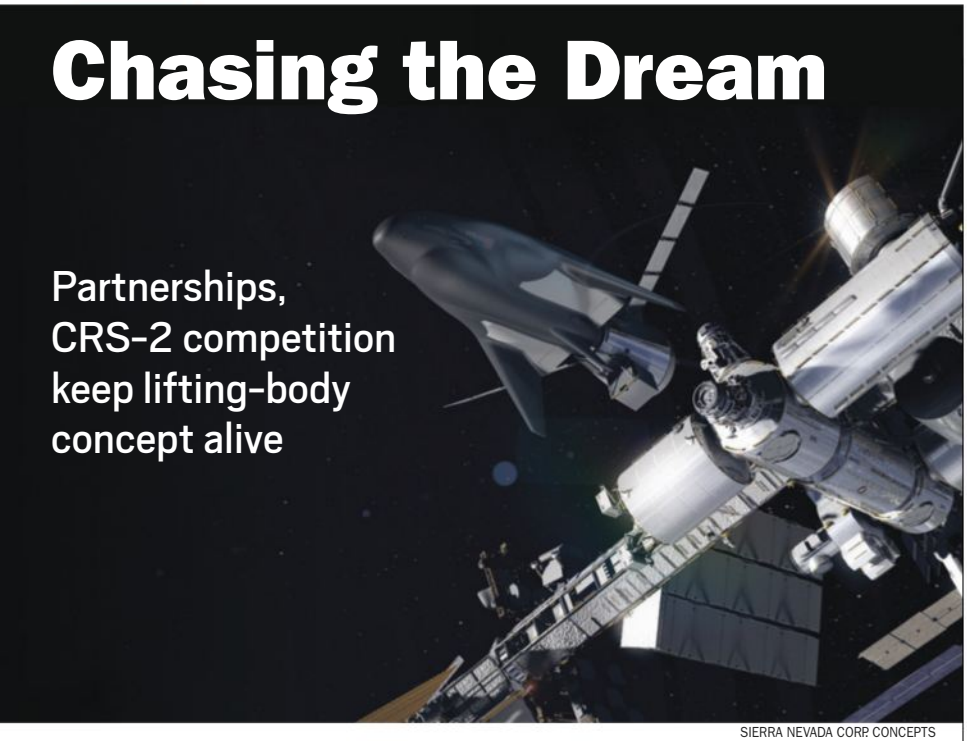
One of the most substantial changes, however, is to the Garmin G3000 avionics, which freshens the look of the instrument panel, says Kelly Peters, Piper senior avionics electrical engineer and software lead.

"The great thing about the G3000 is that it is very easy to use," Peters says. "It's intuitive. If you can operate a smartphone, you can operate the G3000." Three wide-screen 12-in. displays are high resolution and include two touchscreen controllers. Features such as underspeed protection, coupled go around protection, hypoxia recognition, an automatic level mode and a new digital-pressurization system contribute to the user experience.

"Just a new engine would have been good; just a new wing would have been good; just a new avionics package or just a new interior—all of those would have been fine," Athay says. "But together you have a quantum leap in the new product."

Chasing the Dream

Partnerships, CRS-2 competition keep lifting-body concept alive



SIERRA NEVADA CORP. CONCEPTS

Frank Morring, Jr.,
Louisville, Colorado

It lost out in NASA's commercial-crew competition, but Sierra Nevada Corp. has not given up on the Dream Chaser human-rated reusable mini-shuttle.

The atmospheric test vehicle that flew a successful drop test to an autonomous runway landing is in one of the company's buildings here, getting a new set of wings to repair damage suffered when the left main gear did not deploy as it touched down (*AW&ST* Nov. 4, 2013, p. 28). It is scheduled for another drop test—with different landing gear—before the end of the year.

In a separate building, engineers are testing the "iron-bird" version of the orbital vehicle, running all seven of the lifting body's simulated control surfaces through their paces with three flight computers that also are linked to a single-seat simulator down the hall. The first orbital-vehicle composite structure is due to arrive soon from Lockheed Martin.

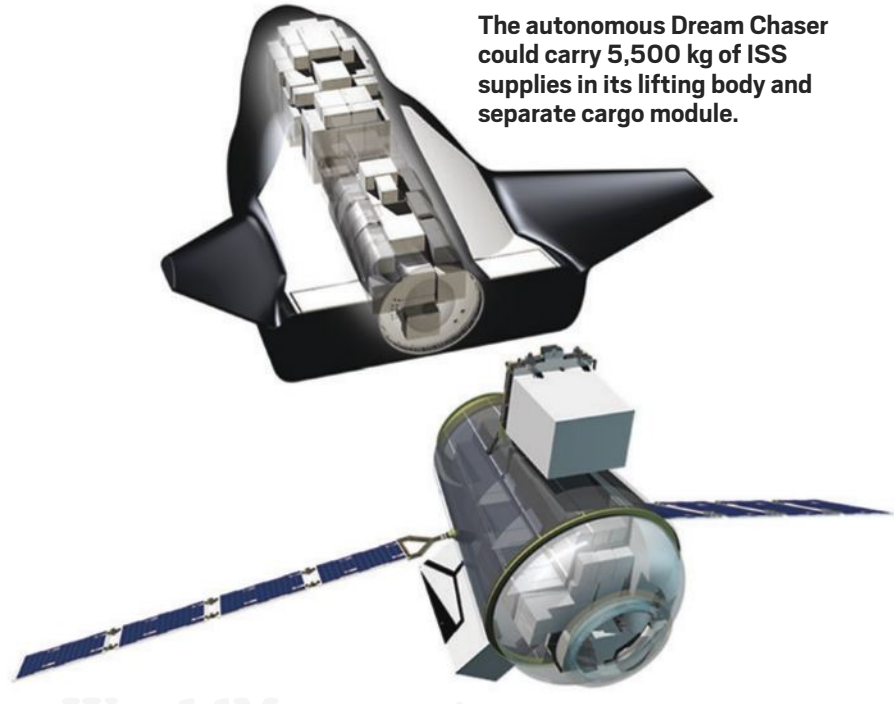
"What we're trying to do is continue to move the vehicle forward, albeit at a slower pace than if we had won the crew competition, but moving it forward in its critical elements so that we have a chance to be able to do test flights with the atmospheric vehicle and then eventually a launch test flight," says Mark Sirangelo, who heads the company's space systems unit. "But clearly we have to get a client in order to do that."

NASA picked capsules built by Boeing and SpaceX for continued development and piloted flight-test under its Commercial Crew Transportation Capability (CCtCap) competition, leaving Dream Chaser without a customer after spending $312.5 million on the vehicle in earlier Space Act agreements. Sierra Nevada, which had put the total spent on developing the vehicle "well over" $500 million with its own investments, formally protested the award.

When the Government Accountability Office rejected the protest, and a federal judge backed the GAO decision, the company pulled up its socks and moved on. It continued development of an unpiloted cargo version of the vehicle as its entry in the second-round Commercial Resupply Services (CRS-2) competition to service the International Space Station (ISS), pitching the vehicle's reusability, large carrying capacity and low-g runway landing as the best fit for the CRS-2 requirements.

Concept of the cargo variant of Dream Chaser arriving at a space station pressurized mating adapter.

"The space station was built assuming the space shuttle would be servicing it, so the whole science paradigm was based on down-mass of pressurized cargo back to a runway so you can get the science in the hands of the scientists. When it goes from 0g back into gravity, it perishes in a few days," says Steve Lindsey, Sierra Nevada's senior director and co-program manager for space exploration systems. "So you wanted to get it back on the runway, go through a gentle entry environment, get it back in the hands of the scientists as soon as possible. When the space shuttle ended, they lost their ability to do that."



The autonomous Dream Chaser could carry 5,500 kg of ISS supplies in its lifting body and separate cargo module.

A former chief of NASA's astronaut corps, Lindsey has flown in space five times and commanded three space shuttle missions to the ISS. As a cargo vehicle, he says, Dream Chaser was designed to hit the "sweet spot" in space-station resupply. It can carry 5,500 kg (11,000 lb.) to the station, which is about the most that can be accommodated with onboard storage.

"Every time a vehicle comes up to the space station, it disrupts normal space station operations," Lindsey says. "So you want to minimize the number of flights that are going up there constantly and docking."

Sierra Nevada engineers have removed everything from Dream Chaser that would be needed if a crew were riding inside—life support, seats, launch-abort motors and even windows—to save weight for more cargo. Riding behind the original lifting-body, which duplicates the mold line NASA developed for its HL-20 experimental vehicle, would be a separate cargo module to carry more pressurized cargo and unpressurized cargo in three off-the-shelf ISS Flight Releasable Attachment Mechanisms (Frams) supplied by Teledyne Brown Engineering.

That would give the vehicle the capability—unique among known bidders for the CRS-2 contract—to deliver pressurized and unpressurized cargo to the station, return scientific samples and other "down-mass" cargo to a 1.5-g runway landing and dispose of space station trash loaded into the cargo module before it is jettisoned to burn up on reentry.

In space, Dream Chaser would dock autonomously with a pressurized mating adaptor, a crew-vehicle requirement that eliminates the need for ISS crew to grapple it with the station arm and berth it to a pressurized module. After reentry and landing, ground crews would be able to open the hatch as soon as it is cool enough to touch and unload its cargo without special protective gear. The reaction control system uses nitrous oxide and propane instead of toxic hypergolic propellants.

The large cargo capacity—twice what NASA required in its request for proposals—also reduces the cost of launch, which Sirangelo notes is the most expensive part of the mission because Dream Chaser, and its CRS-2 competitors, all ride to orbit on expendable launch vehicles. The cargo version will have wings that fold into a standard Ruag 5-meter fairing for launch, making it compatible with the Atlas V launch vehicle baselined for the crew version, Europe's Ariane 5 and perhaps other launchers as well.

SIERRA NEVADA CORP. CONCEPT

Folding wings inside a 5-meter fairing would make Dream Chaser compatible with the Ariane 5 as well as the Atlas V.

"If there's some issue with the Atlas and the motors, we now have a viable backup," Sirangelo says of the ongoing concern over availability of the Russian-built RD-180 rocket engine that powers the Atlas V main stage.

The company continues to work with NASA on developing Dream Chaser. The remainder of its $212.5 million Commercial Crew Integrated Capability (CCiCap) contract will fund the upcoming second drop-test milestone, and it is working with experts across the agency under various unfunded Space Act Agreements to continue to push development. Sierra Nevada also counts the European Space Agency (ESA), Japanese Aerospace Exploration Agency (JAXA) and the German Aerospace Center (DLR) among more than 30 partners in the work.

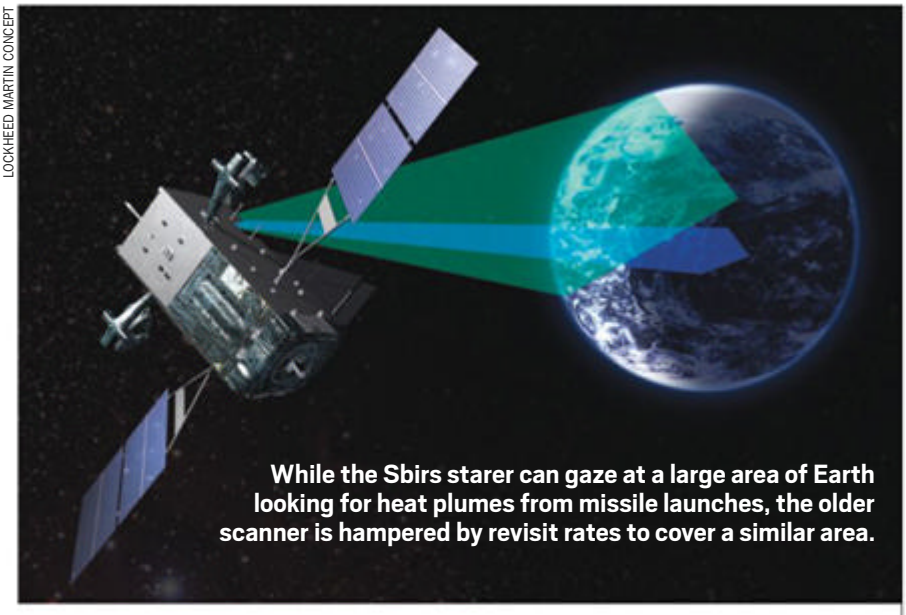
Sirangelo and DLR chief Johann-Dietrich Woerner, who is scheduled to take the helm at ESA on July 1, signed an agreement April 16 extending their organizations' partnership another three years. Among German interests in the Dream Chaser is robotic satellite servicing and retrieval of defunct spacecraft, Sirangelo says.

JAXA is using its expertise in orbital laboratory design to help Sierra Nevada develop a free-flying laboratory variant of the Dream Chaser, while the company continues to work quietly with Stratolaunch Systems on an air-launched subscale variant.

"The core cargo vehicle gives us a fully autonomous long-duration vehicle for space," Sirangelo says. "While the mission is for NASA, and there are certain elements of it that allow us to go to the space station, all the things that are necessary to fly this vehicle fully autonomously allow us to look at other missions as well. We might not need the cargo container. We might replace it with robotics. We might replace it with something else, or we can turn it into a long-duration laboratory. So all the work we're doing to meet NASA's cargo requirements is very valuable to other potential missions as well."

If the CRS-2 contract does not pan out either, Sirangelo says the 3,000-employee private company has plenty of other irons in the fire to keep the Dream Chaser program going, including a new operation it is launching in Colorado Springs with plans to employ 2,100 workers customizing large-frame airliners for heads of state, corporations and wealthy individuals. In February it acquired 328 Support Services GmbH, which holds the type certificate and intellectual property rights for the Dornier 328 fleet of aircraft.

"We have a good growing business outside of this," Sirangelo says. "It's not the end of the world for us as a company if we don't do it. We didn't get the huge contract that we wanted, but on the other hand, we didn't have it budgeted in either, so it's an interesting position to be in."



LOCKHEED MARTIN CONCEPT

While the Sbirs starer can gaze at a large area of Earth looking for heat plumes from missile launches, the older scanner is hampered by revisit rates to cover a similar area.

Finally Ready To Stare

With Sbirs infrared starer assessment underway, Pentagon works to speed data to soldiers

Amy Butler Colorado Springs

Four years after launch of the first of a new fleet of missile-warning satellites, the U.S. Air Force is planning to test the system's newest technology—a powerful infrared staring sensor—in an operational assessment.

The operational assessment is set to begin in November and last 5-6 months, according to Jeff Smith, vice president of military space programs-operations at Lockheed Martin, which manufactures the Space-Based Infrared System (Sbirs) satellites. Meanwhile, the Air Force is pushing to send as much as possible of the Sbirs data—described by Air Force Space Command chief Gen. John Hyten as "eyewatering" at the 31st Space Symposium here April 13-17—to tactical users in the field. It is also establishing a distribution hub for all satellite infrared data (including classified products from the National Reconnaissance Office) for users globally.

Each step forward for Sbirs is a major accomplishment. The $18.7 billion program was frequently on the chopping block and has dealt with numerous requirements changes and technical delays. The changes included the late addition of a sun shade for the infrared scanner and starer, tackling significant problems related to controlling electromagnetic interference and dealing with a processor issue late in development. The program's cost spiked 284% since its inception, belying Lockheed's overly ambitious promise of an inexpensive, quick delivery.

Two Sbirs geosynchronous satellites are now in orbit, as are two scanner payloads on classified host satellites in highly elliptical orbit (HEO). They are augmented by remaining Defense Support Program (DSP) satellites, which employ older infrared scanners for detecting hot missile plumes. The scanning infrared sensor was declared operational and certified for use in detecting threats via the Integrated Threat Warning/Attack Assessment System (ITW/AA) in May 2013.

Sbirs, like DSP before it, would probably be the first warning of a hostile ballistic missile launch. The scanner sensor literally scans areas of the Earth with a classified revisit rate. The starer, however, is a large focal plane array not hindered by revisit rates. It can also "zoom in" on an area when cued by the scanner to glean more data, such as technical intelligence on a launch.

Data from the advanced Sbirs starer—which, along with the older scanner, comprise the Northrop Grumman payload—are being fed to the National Air and Space Intelligence Center, Smith says. The center is responsible for gathering intelligence on foreign missile systems. Although designed for missile warning, part of the ambition behind Sbirs was to include the starer to help with battlespace characterization and intelligence collection on foreign ballistic missiles.

"They are using the starer in analytic products in an R&D manner," Col. Mike Guetlein, the Air Force's production manager for Sbirs, said at the symposium. The operational assessment is required for the data to be verified and officially accepted.

While working toward ITW/AA certification for the starer, the Air Force and intelligence community are establishing a Remote Real-Time Transfer Service, what Guetlein describes as a distribution hub for all overhead-persistent-infrared data including, eventually, material collected from aircraft. Ultimately, such a hub is expected to help with alerting tactical forces—those deployed globally—to infrared events such as missile attacks. Critics of Sbirs and other similar systems suggest their data are too slow to reach users in the field and are coveted by national analysts in the U.S.

During the Iraq and Afghanistan wars, however, operators were able to "tune" data from the DSP to help soldiers on the ground.

The new starer technology has presented challenges. It has taken a long time to gain certification because of the complexity of the data-set collected, and the techology will become increasingly complex as the service looks to employ wide-field-of-view starers in a follow-on architecture.

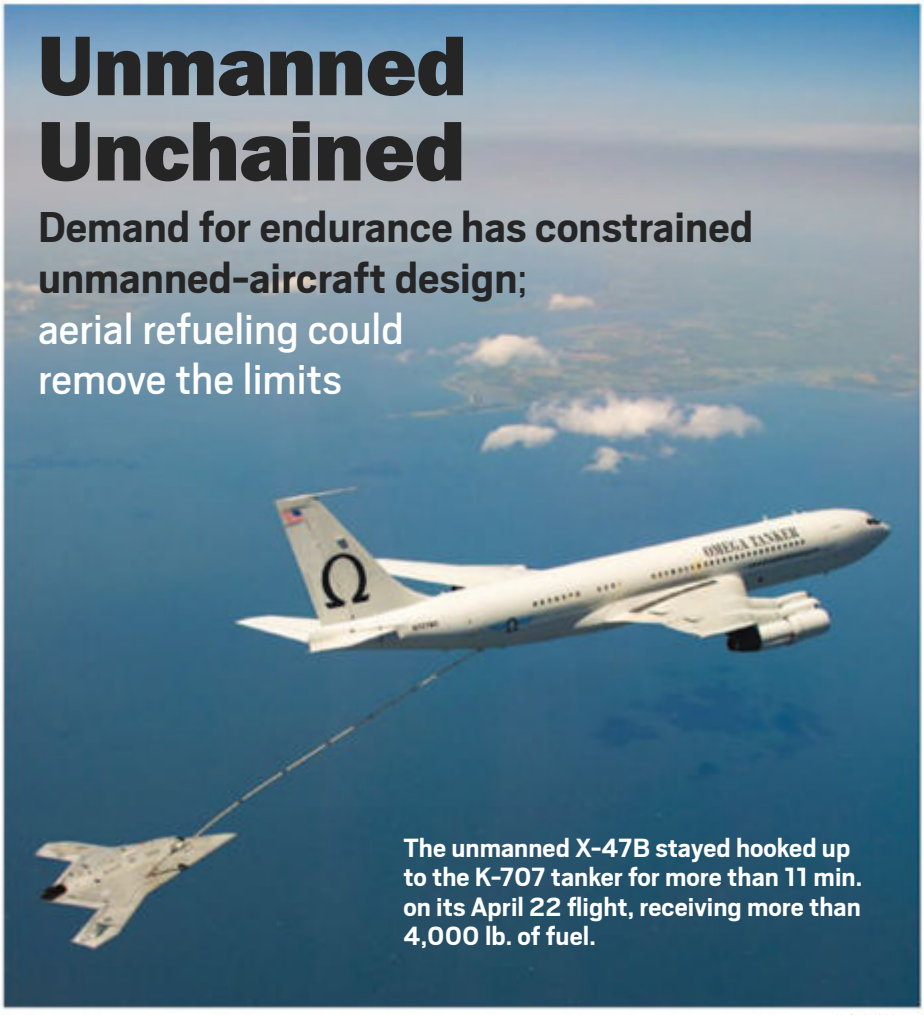
Meanwhile, the Air Force is continuing to study options for a next-generation architecture, with the door open to "disaggregating" it for future systems. This could provide resiliency—with only four satellites envisioned for Sbirs, a hostile act toward one could blind the U.S.—as well as reduce the complexity of the satellite design.

The third Sbirs satellite (GEO-4) will be delivered this summer and the fourth (GEO-3) is scheduled for next spring, Guetlein says.

HEO-4 is being delivered for integration on a classified host payload next month, Smith says. Lockheed Martin was awarded a contract last June to build Sbirs GEO-5 and -6, and parts are on order, he adds.

Unmanned Unchained

Demand for endurance has constrained unmanned-aircraft design; aerial refueling could remove the limits



The unmanned X-47B stayed hooked up to the K-707 tanker for more than 11 min. on its April 22 flight, receiving more than 4,000 lb. of fuel.

U.S. NAVY

Graham Warwick Washington

One defining characteristic has given unmanned aircraft their foothold in aviation—endurance. Leave out the pilot and an aircraft can fly for longer. But engineering for persistence is a straitjacket that has constrained designers' options—until now.

Northrop Grumman, whose slender-winged, slow-flying Global Hawk helped define persistence with its 30-hr.-plus endurance, thinks one event has removed those design limits: the first autonomous aerial refueling of an unmanned aircraft. It was a different Northrop product that achieved that feat on April 22, when the U.S. Navy's X-47B unmanned combat air system demonstrator (UCAS-D) took on fuel in flight from an Omega Boeing K-707 tanker off the U.S. East Coast.

It was the second historic aviation milestone for the flying-wing X-47B, which in July 2013 made the first unmanned-aircraft arrested landings and catapult takeoffs from an aircraft carrier at sea. "Taking fuel autonomously from a tanker is way more important to aviation than landing on a carrier," says Scott Winship, vice president for advanced air warfare development at Northrop Grumman Aerospace Systems. "It's the most important development for unmanned aircraft since waypoint navigation, because it gives you all the tools that manned aircraft have."

The autonomous aerial refueling demonstration was the final phase of the $1.47 billion UCAS-D program. "This is historic, the first demonstration of an unmanned aircraft autonomously approaching the tanker, engaging, receiving fuel and safely disconnecting," says Capt. Beau Duarte, Navy program manager for unmanned carrier aviation. "It was autonomous, not remotely piloted. The operator commanded software subroutines, which the mission computer on the aircraft translated into commands. The computer got the aircraft into the moving basket for the first time."

While the demonstration has clear implications for the Navy's planned Unmanned Carrier-Launched Airborne Surveillance and Strike (Uclass) program (see page 66), Winship argues the achievement has wider implications. "We can take on fuel and go for days with aircraft designed for what we want them to do. We can trade fuel for speed, stealth or range," he says. "The first big leap was to take the human out of flying in the aircraft. The second is knocking down the limit on persistence."

Long-wing, long-endurance aircraft may still have their place, Winship says, but it will now be possible to design aircraft for other attributes and still have the advantage of persistence over manned aircraft. "Flying real slow, long glider wings, using diesel fuel and Caterpillar engines—those are things we do to get the benefit of endurance, but they have penalties in payload, how fast we can fly and what missions we can do," he says. With the demonstration of autonomous aerial refueling, "from this day forward it is open season on how we design unmanned aircraft."

Northrop came close to demonstrating unmanned aerial refueling once before, in 2012, with a pair Global Hawks under Darpa's Autonomous High-Altitude Refueling, or KQ-X, program. But the approach used there was unique to the challenge of refueling long-endurance unmanned aircraft at high altitude, where both tanker and receiver are close to stalling and have only limited maneuverability.

That approach was to use two Global Hawks, one to refuel the other, the receiver flying ahead of the tanker in a reversal of normal probe-and-drogue refueling. The receiver aircraft, equipped with a hose reel under the fuselage, would deploy the trailing drogue and the tanker Global Hawk, fitted with a refueling probe, would maneuver into contact with the basket and "push" fuel to the receiver.

Darpa and Northrop planned to demonstrate autonomous high-altitude refueling using NASA's two RQ-4A Global Hawks modified as receiver and tanker. In May 2012, the two aircraft flew in close formation, 100 ft. or less between probe and drogue, for most of a 2.5-hr. test at 44,800 ft. altitude. But because of modification delays, and NASA's need to use the Global Hawks for planned hurricane tracking flights, the KQ-X program ended without aerial refueling being accomplished.

Navy-style probe-and-drogue refueling is a demanding mission, even for a manned aircraft. "It's a high-gain task, with a lot of fine maneuvers," says Duarte. "Probe-and-drogue is the hardest problem to solve. First you have to fly in formation, then catch the basket," says Winship. "Originally it was part of the program to do it both ways—probe-and-drogue and boom—so we can get fuel from the Air Force's big-wing tankers." The aerial refueling demo had been dropped from the Navy's UCAS-D program, but was reinstated when Congress provided additional funds.

The April 22 mission began with X-47B air vehicle 2, call sign Salty Dog 502, taking off from NAS Patuxent River, Maryland. AV-2 was equipped with a fixed refueling probe for the test. Although both X-47Bs were designed to accommodate a retractable, stealthy probe, "for the first demonstration of aerial refueling it was not critical to have a deployable probe. We've done that before," Winship says.

The K-707 tanker, meanwhile, was on station off the coast, "leaving breadcrumbs" for the UCAS-D to follow. "The X-47 calculated its vector, where the tanker was going and calculated a route to close in on its trail," he says. The unmanned aircraft located and rendezvoused with the tanker using the same centimeter-accuracy precision-GPS relative navigation system used to land the UCAS-D on the carrier. Both the X-47B and K-707 were equipped with redundant global-positioning/inertial-navigation systems (GPS/INS) and exchanged position information via high-integrity, low-latency TTNT data links.

Although the operating concept is for the unmanned aircraft to follow the same refueling procedures as a manned aircraft, taking up an observation position off the tanker's wingtip before dropping back to line up with the drogue, for test efficiency the X-47B acquired the extended centerline of the tanker and approached straight in from astern, says Duarte.

The UCAS-D closed to 1 mi. behind and 1,000 ft. below the tanker, then requested permission to move in from its operator on the ground at Patuxent River. "When it stabilized, the operator commanded the next move, to a half-mile, a quarter-mile, 200 ft. in trail," says Duarte. "Our test objective was to ensure it was safe and stabilized before proceeding to the next step. Operationally, it would be a bit more expeditious."

Closing to 20 ft. behind and co-altitude with the drogue, called the "poise" position, the X-47B switched from tanker-relative navigation using differential GPS to drogue-relative navigation using a vision system on the unmanned aircraft. This comprises two electro-optical and two infrared cameras mounted flush to the airframe and provides a three-dimensional image of the tanker and drogue.

The visual system was developed so as to avoid requiring changes to the tanker, such as a steerable drogue. Modifications made to the K-707 for the test were limited to adding the triple-redundant GPS/INS, TTNT data link and a control station to allow the tanker operator to monitor the refueling operation and command the unmanned aircraft to break away if required for safety.

A visual computer installed in the UCAS-D tracked the tanker's wingtips, engines, tail and the drogue "as a series of dots," says Winship. After tracking the basket precisely over a number of frames, the aircraft entered drogue-relative mode, the visual computer generating guidance and control commands. The aircraft then began to follow the basket, while still monitoring the tanker position, but with the flight-control gains turned down so as not to chase the drogue, he says.

Once the unmanned aircraft was stabilized behind the drogue, either of the operators on the ground or in the tanker could give the command to engage —the UCAS-D made five engagements during the tests, the last culminating in fuel transfer. On command the X-47B moved forward to push the probe into the basket and drive the drogue 10 ft. forward to take tension off the hose and ensure that aerodynamic drag on the drogue kept the nozzle engaged.

Once hooked up, the X-47B transitioned back to tanker-relative navigation and followed the K-707 through two turns as it took on fuel. The objective was to transfer at least 3,000 lb. of fuel. In the end, the UCAS-D stayed hooked up for more than 11 min. and received more than 4,000 lb. of fuel. The demo objectives met, the ground operator commanded the aircraft to disengage and the X-47B dropped back at 5 ft./sec. to the poise position, then broke away and returned to Pax River.

"It worked like clockwork," says Winship. "It looked kind of easy, but enabling a new set of design criteria is a big deal." The UCAS-D was designed with high-rate flight controls to ensure the tailless flying wing could land precisely on a moving aircraft carrier. This added expense, but also ensured the X-47B could follow the drogue without any control lag. "A flying wing is inherently not as agile, so we are probably about double what we could be at," says Winship, adding Northrop will be looking at the aerial-refueling test data "to figure how much we can turn down the flight controls."

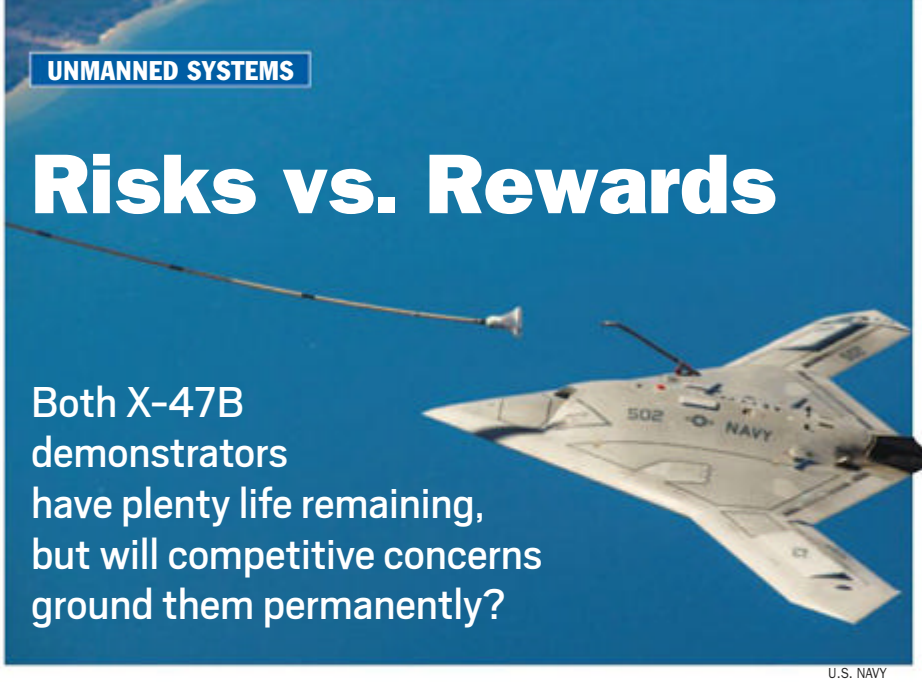
Although there are no plans to demonstrate Air Force-style boom refueling of the X-47B, Winship says the same system will work: precision-GPS relative navigation to rendezvous with the tanker, then the visual system to hold precise position while the boom operator on the tanker flies the nozzle into the refueling receptacle. The X-47B is designed to accommodate the F-117's stealthy flip-over receptacle. "Boom refueling would be great. The Air Force carries most of the gas and they have the real big wings needed to enable global persistence and strike," he says.

Winship says autonomous aerial refueling could shape design of the Air Force's eventual replacement for the MQ-9 Reaper as well as future Navy unmanned aircraft. "A carrier aircraft is a certain size, around 50,000 lb. If the primary design driver is unrefueled range then you put fuel in every corner and it gets fatter, and slower for efficiency, and you drive out any ability to have speed and payload or it gets too gargantuan," he says. "But now you are able to trade off on a carpet plot how much unrefueled range, how much refueled, how much payload. You can make it as fast as you want—before, you could never go fast because you used too much fuel. And you can have long edges to make it very stealthy. There is a huge change in the trade space you have on the carpet plot."

Persistence is what unmanned aircraft are good at, says Winship. "There is only one reason to go unmanned and that is to persist deep in enemy territory to look for emergent targets—like Scud- hunting in Desert Storm," he says. "And persistence at range is enabled by autonomous aerial refueling. Tankers can stand off 800 nm and unmanned aircraft can fly unrefueled for 1,000-1,200 nm and then come back to refuel. We've knocked down the barrier to persistence."

Risks vs. Rewards

Both X-47B demonstrators have plenty life remaining, but will competitive concerns ground them permanently?



U.S. NAVY

Graham Warwick Washington

Museum exhibits or risk-reducers? That is the choice facing the U.S. Navy as it decides what to do with its two Northrop Grumman X-47Bs now that the planned unmanned combat air system demonstration (UCAS-D) program is complete. And the conundrum: Continuing to fly the aircraft risks unbalancing the competition for the follow-on Unmanned Carrier-Launched Airborne Surveillance and Strike (Uclass) system.

Given the controversy already surrounding the Uclass program, the Navy probably would prefer to retire the X-47Bs quietly, however valuable their continued operation might be. But the service may not have that option. Senate Armed Services Committee Chairman John McCain (R-Ariz.) is a fan of UCAS-D, even tweeting news of the aerial refueling demonstration on April 22.

In late March, McCain sent a letter to Defense Secretary Ashton Carter outlining his desired attributes for an operational carrier-based unmanned aircraft and encouraging the Navy to continue flying the X-47Bs "until a restructured Uclass program yields flying prototypes . . . in order to gain technological and other insights that could help increase the effectiveness of the Uclass program."

Noting both air vehicles "have consumed only a small fraction of their approved flying hours," McCain expressed concern that "under current plans, starting this April, there will be no unmanned air vehicles operating from carrier decks for several years"—a gap he characterized as "a lost learning opportunity."

That gap has now opened with the demonstration of autonomous aerial refueling (AAR) and completion of planned activities under the $1.47 billion UCAS-D program. But the Navy still has some funds remaining from the $35 million provided by Congress in fiscal 2015 to add the AAR demonstration back into the program. The Navy is in a cleft stick. Carried over from the Darpa/Air Force/Navy Joint Unmanned Combat Air Systems program canceled in 2006, the X-47B was designed from the ground up as a demonstrator. Compared with Uclass "it has a different architecture, a different landing system, a different control station—it was never intended to directly transition to operation," says Capt. Beau Duarte, the Navy's program manager for carrier unmanned aviation.

Any changes to the X-47Bs to make them more Uclass-like, and more useful for risk reduction, would be expensive and risk tilting the Uclass competition toward Northrop Grumman and away from rivals Boeing, General Atomics and Lockheed Martin. "We have a range of options, from sending them to museums to further ground or flight operations, but we have to keep the playing field level for Uclass," says Duarte.

An example is aerial refueling, which the Navy has called finished after five engagements, the last of which resulted in the transfer of fuel. Some, including Northrop, would like to see the Navy expand the UCAS-D's refueling envelope. "We are not interested in optimizing X-47B refueling. We met the initial objective to show the feasibility of autonomous aerial refueling," says Duarte.

"The visual system is just one approach," he notes, referring to Northrop's camera-based system to enable the unmanned aircraft to navigate precisely relative to the refueling drogue. "Different contractors have different solutions. When we have a Uclass selected, the refueling solution will be specific to the design and we will need to optimize that."

With only limited money remaining, continued use of the X-47Bs likely will require additional funding to be identified. There is a range of options for Uclass risk reduction, says Duarte, including deck-handling trials, flying mission sensors and integrating the precision landing system that will be used with Uclass. "There is a range of things with different price tags and different competitive implications that we are talking through with Navy leadership," Duarte explains.

X-47B Air Vehicle 2 prepares to engage the K-707 tanker's drogue with its fixed refueling probe.

To be useful assets for risk reduction, the demonstrators likely would need "fairly expensive" modifications. "The more Uclass-like the X-47B gets, the more implications it has for competition, so we would have to share some of the data [with the other competitors]," Duarte says.

The Uclass requirements, a matter of heated debate, are due to be finalized this summer as part of a Navy strategic portfolio review.

McCain has made clear his position, the March letter to Carter calling for Uclass to be able to perform strike as well as surveillance missions "with an unrefueled endurance several times that of manned fighters; a refueled mission endurance measured in days; broadband, all-aspect radar cross-section reduction sufficient to find and engage defended targets; and the ability to carry internally a flexible mix of up to 4,000 lb. of strike payload."

Duarte says the exact Uclass requirements for aerial refueling—tanking and receiving—are still under discussion, but Northrop's position seems clear: Autonomous aerial refueling could enable a stealthy strike aircraft to also perform the persistent surveillance mission. "If you can carry 4,000 lb. less gas you can carry a 4,000-lb. payload like the F-35," says Scott Winship, vice president of advanced air warfare development.

Gallery *See a timeline in photos of the record-setting X-47B demonstration program:* **AviationWeek.com/X-47B**

Qualifying Carbon

Public-private partnership tackles the cost and time required to certify composite structures

Graham Warwick Washington

Testing required to develop and certify aircraft structures has increased dramatically with the growing use of carbon-fiber composites, and the cost and time required have become an issue as industry looks for further improvements to reduce fuel burn.

Now NASA has formed an industry-spanning consortium with the goal of cutting by 30% today's 10-year timeline for developing and certifying composite aircraft structures. The public-private partnership of NASA, the FAA, Boeing, GE Aviation, Lockheed Martin and a United Technologies Corp. team led by Pratt & Whitney plans to conduct joint research under the five-year Advanced Composites Program (ACP).

With growth in use of composites to around 50% of structure weight in the Boeing 787, the number of material property tests during development has increased to 100,000 from 5,000 in the 1980s, and structural element tests to 10,000 from 500, says Eric Cregger, senior technical fellow in structural technologies at Boeing Research & Technology. "The increase in cost and time to develop and certify is becoming an issue," Cregger told a manufacturing technology conference in Chicago in September. "The time to develop a next-generation aircraft is more than 210 months and going up."

"The lack of accepted analysis and test protocols that can be used to provide consistent understanding of the damage tolerance, production process variability and long-term durability of composites" is a significant problem, says NASA. "To assure product safety, developers must rely on time-consuming and costly testing procedures resulting in high development cost and long certification times."

ACP will focus on three technology challenges to developing and certifying composite structures: predicting damage, rapid inspection, and manufacturing processes and simulation. The program was funded in NASA's fiscal 2013 budget but has taken time to begin because of the complexity in agreeing how the companies will collaborate and share data from their proprietary experiences, to develop industry standards to characterize the as-manufactured behavior of composite structures.

The key final step was to appoint an integrator to manage the program and distribute NASA funding to the partners, which will share in the cost of research projects. The National Institute of Aerospace (NIA) in Hampton, Virginia, close to consortium-member NASA Langley Research Center, has been selected. "NIA is developing sub-agreements with the individual companies. They are just about there," says NASA Langley's Stan Smeltzer, ACP deputy program manager.

A draft of up to 20 research activities for Phase 1 of ACP has been taking shape in the past six months, and the first projects should begin by mid-year. The goal is to have multiple partners involved in each research project, where possible. "The more partners are working together, the more value there is, so we favor projects with multiple partners," Smeltzer says.

Because of the delay in establishing the public-partnership agreements, Phase 1 will now end in fiscal 2016. There then will be a downselect for those projects that continue into Phase 2, which is planned to end in fiscal 2018.

The predictive capabilities technical challenge is intended to develop composite damage-prediction methods sufficiently reliable to enable a reduction in the element and subcomponent testing necessary for development and certification. ACP also is expected to create rapid design tools to speed preliminary design and reduce redesign.

Developing methods to predict defects in carbon-fiber laminates is a key object of NASA's Advanced Composites Program.

The rapid inspection challenge is intended to develop methods to find, quantify and pass data on the majority of aircraft-manufacturing composite defects back for analysis within the digital design environment. ACP also will identify automated inspection and analysis methods and develop a baseline of standard practices for ranking candidate techniques.

NASA PHOTOS

Faster development and certification could speed new designs such as NASA and Boeing's Prseus stitched-composite structure.

The manufacturing process and simulation challenge is aimed at developing predictive tools to speed design, analysis and fabrication; predict defects induced by automated fiber placement; and improve the ability to process fiber-placed structures. ACP also has the goal of enhancing the ability to adhesively bond composites for more-efficient structures, says Smeltzer.

ACP is unusual for NASA, which does little research on manufacturing technology. Smeltzer says its role will be to bring an understanding of the physics of composites to bear on existing manufacturing processes to drive out defects.

No Sanctuary

Pentagon finally puts up money to defend space assets

Amy Butler Colorado Springs and Washington

The White House has requested that $5 billion be allocated for new initiatives over the next five years for space control, reflecting a realization sharpened since China's latest anti-satellite test last year that allied spacecraft are no longer safe once in orbit.

The funding speaks to the urgency behind the mission. It comes as the Pentagon is being pressured to reduce defense spending. It is not "new" money but has been generated by cutting other projects at a time when many military programs lack extra cash.

The rhetoric, however, is murkier. Many senior officials shy away from using the term "space control," though it is codified in Joint Doctrine, as noted by Air Force Space Command chief Gen. John Hyten. That term, some say, is too bellicose, pointing to space militarization projects and harkening to days when President Ronald Reagan eyed lasers and interceptors in space.

The funding is nonetheless needed for space surveillance as well as protecting assets in orbit. The Pentagon has been far more secretive on the latter than the former, as most defensive systems and measures also can be used for offensive operations. And Pentagon officials do not want to start a war in space with actions or words.

But many space capabilities—such as GPS, weather monitoring and prediction and Earth observation—are woven into the fabric of the U.S. and its allies' economies, not simply military requirements. Failing to protect them would expose a major vulnerability for U.S. interests. Unlike in air and sea—where U.S. armed forces can be used liberally to project economic interests even abroad—operating in space is thornier because Washington is a signatory to a treaty barring the militarization of space. Many senior U.S. officials are using the term "space protection" to avoid fears that the Pentagon is arming the "final frontier."

Hyten says the money is set aside for several projects. Among them is acceleration of the Joint Space Operations Center Mission System (JMS) and follow-ons to two satellite projects designed specifically to spy on other satellites in space. The JMS acceleration reflects a desire by Air Force space commanders not only to know what objects are in space but to react—or have positive command and control in the event they need to react.

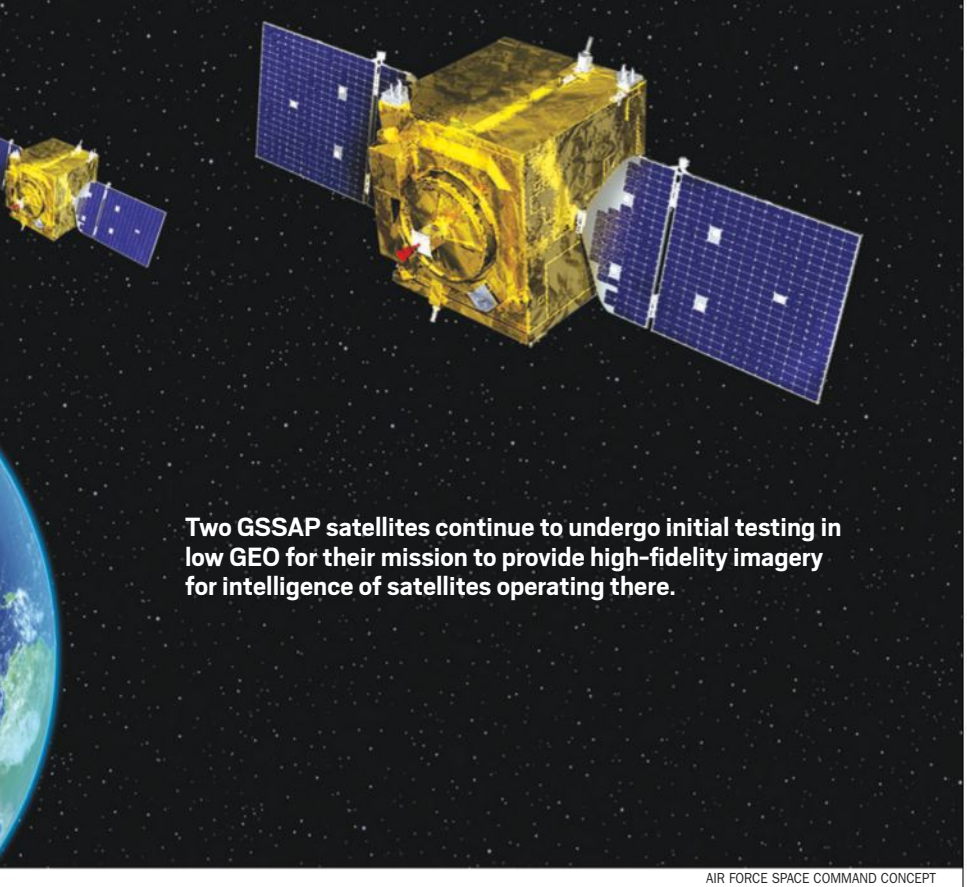
Air Force space officers have long outlined a need for such a capability. But this message is now spreading into the mainstream of Air Force, Pentagon and national security leadership thanks largely to developments from potential adversaries to counter U.S. and allied capabilities in space. The most public has been China, which downed its own aging weather satellite orbiting about 500 mi. above Earth in 2007. While many space officials hoped this would be a long-awaited wake-up call to national leaders for the need to bolster space capabilities, it was not. Instead, they focused primarily on the issue of debris, a large amount of which was created by the hasty test and still remains in orbit, say industry sources in the U.S.

Not so for the July 24, 2014, trial by China characterized by the U.S. State Department as a nondestructive anti-satellite test. Chinese officials chafe at that characterization. But industry sources here suggest an interceptor "went way up high—into or close to geo [synchronous orbit]—and came back down," a bold action forcing Pentagon officials to consider a reality where the missile warning and communications satellites so integral to military operations could be attacked. These are only the publicly acknowledged developments; industry sources say there are still more that remain secret.

Last summer, the Pentagon conducted a sweeping Space Posture Review, which prompted the White House to direct the extra funding for space control. Many of the review's findings are classified, but Lt. Gen. Ellen Pawlikowski, military deputy to the Air Force procurement secretary, outlined them in general during a recent breakfast meeting on Capitol Hill.

In the past, space system designers focused largely on a "hunker-down" mentality, hardening satellite designs against electromagnetic interference. Now, she says, these systems are under threat. And military planners are examining ways to make satellite architectures more resilient. This includes "disaggregating" systems—splitting what were once a single satellite's functions into those on many disparate spacecraft—as well as backing up space capabilities with systems in the air or on the ground. It also could point to a need for localized augmentation, as in the case of GPS. Finally, reconstitution is on the table; military planners may be required to build extra spacecraft to loft replacements into orbit quickly in the event of attacks.

These principles are being considered as the Pentagon prepares for a new wave of space procurements: mainly those to continue the missile warning service now provided by the Space-Based Infrared System (Sbirs) and communications provided by the Wideband Global System, Advanced Extremely High Frequency (AEHF) and Mobile User Objective System satellites. Two analyses of alternatives (AOA) for follow-ons to Sbirs and AEHF are coming due this summer, says Douglas Loverro, deputy assistant secretary of defense for space policy. The findings will be used to launch new programs, likely costing in the billions of dollars. One reason these AOA have been long overdue is they "ran



Two GSSAP satellites continue to undergo initial testing in low GEO for their mission to provide high-fidelity imagery for intelligence of satellites operating there.

AIR FORCE SPACE COMMAND CONCEPT

into the problem of trying to figure out how to react to threats," Loverro told Aviation Week during an April 15 interview at the 31st Space Symposium in Colorado Springs. These satellites will not likely be launched until at least 2025, but planning is underway to incorporate lessons from the Space Posture Review into their designs.

The Air Force also is planning to update its tactics, techniques and procedures, as well as operational concepts for space assets, to reflect the reality that satellite systems are no longer uncontested. "We can no longer assume that we will not be involved in protecting assets against attempts to deny" their service to us, Pawlikowski says.

Another finding from the review is the need for better cooperation with commercial and international operators, Pawlikowski says. Already, plans are underway to establish a pilot program to improve data exchange among commercial and military operators.

The so-called Commercial Integration Cell (CIC) will begin operations for a six-month trial this summer in the Joint Space Operations Center (JSPOC), an integrated situational awareness and command-and-control center ultimately reporting to U.S. Strategic Command. The JSPOC, at Vandenberg AFB, California, is headed by Lt. Gen. Jay Raymond, 14th Air Force commander.

The goal is to improve the "machine," or computer, interfaces between commercial operators and the military. Ultimately, however, during the six-month pilot period, commercial and military operators hope to establish better techniques for reporting on and tracking space objects, says Kay Sears, president of Intelsat General, a key supplier of satellite communications for the Pentagon.

Raymond announced that the CIC will begin operations in June, during an April 10 breakfast on Capitol Hill hosted by the Air Force Association's Mitchell Institute. He says the JSPOC tracks 23,000 objects in orbit, a number expected to increase with intelligence to come from the two new Geosynchronous Space Situational Awareness Program (GSSAP) satellites lofted July 28, 2014, to surveil other spacecraft operating in geosynchronous orbit (GEO) using onboard cameras. The CIC "will help us with [space situational awareness], it will help us with electromagnetic interference and it will help the commercial folks, as well, understand what the threat up there is," Raymond says.

During the pilot phase, the CIC will include operations 8-12 hr. per day; operators will be on call in the event of an urgent issue, Sears tells Aviation Week. The cell could be expanded to round-the-clock operations eventually. During the pilot period, operators hope to establish what type of "machine-to-machine" interfaces are needed to better share data among the military and commercial users.

Also, Sears says, operators hope to hone operational concepts (conops) and procedures for various scenarios of events that can happen in space, from the most dramatic, such as a satellite collision or attack, down to routine friendly electromagnetic interference. "How do we leverage the interference location systems and quickly identify where interference may be coming from? How do we characterize it? What are you seeing? What we are seeing? Is this happening among other systems? Is there some kind of correlation of that data?" Sears asks, acknowledging some of the issues facing disparate operators. "We don't necessarily have a great conops for how we do that right now. . . . That is not really a good practice." Establishing those practices also will lead to improved training for operators.

Sears says the CIC pilot is to be a two-way data exchange involving input from both military and commercial users. The CIC will include personnel and resources from six commercial operators supporting the Pentagon: DigitalGlobe, Eutelsat, Inmarsat, SES, Intelsat and Iridium. However, other commercial operators will benefit. The CIC is to act as a representative and umbilical cord for the industry inside the JSPOC.

Fairly routine processes are in place for the most dire events in space, such as satellite collisions. But with the CIC, the same rigor can be put behind processes and procedures surrounding mundane interferences and, possibly, help identify them if insidious forces are at play, by providing more data to operators about anomalous events.

Eventually, the hope is that commercial and defense operators can be trained in the standardized procedures to be formed through the pilot project.

Commercial operators have long argued for better cooperation with the Defense Department and intelligence community. The CIC is one of several initiatives at the Pentagon to improve its space posture. The 2014 anti-satellite test by China, which is the only publicly acknowledged demonstration of a kinetic threat to satellites in geosynchronous orbit, is a driving force behind a newfound unity among U.S. government officials on the issue of space control, according to industry sources.

The CIC will include information technology support from the JSPOC and space on the operations center floor.

Continued from page 74

HAFFA

ducing sustainment costs, which can total up to 80% of a weapon system's life-cycle cost, has resulted in the B-2 costing less per aircraft than other large Air Force aircraft of similar fleet size. Sustain a B-2 for less than an RC-135? Northrop's experience enables it. In contrast, although the Boeing/Lockheed team will tout its experience in building large commercial airliners and fighter aircraft, producing and sustaining an advanced bomber is a complicated enterprise demanding relevant leadership and engineering talent. Past performance matters. Building a B-2 is a far more complex undertaking than modifying a commercial aircraft into a tanker, yet Boeing is still struggling to deliver the KC-46 a decade after initiating development.

The capability to integrate stealthy subsystems. The Air Force understands that stealth is a combination of technology and tactics, calling for the integration of subsystems enhancing the aircraft's low observability. Here Northrop shines with its stealth subsystems credentials. When Lockheed needed such systems, it turned to Northrop Grumman for stealth radar on the F-22 and F-35, stealthy communications links for the two fighters, and the F-35's communications-navigation systems, infrared sensors, and center fuselage with its stealthy engine inlets. The Defense Department also will push an unmanned variant of the LRS-B; Northrop Grumman's experience with the Air Force Global Hawk and Navy's stealthy unmanned X-47B places it well ahead of the competition.

Why Northrop Grumman will win. The Air Force needs a contractor dedicated to bringing in the LRS-B on time and on budget, yet Boeing and Lockheed are teamed because neither is positioned to win alone. Boeing lacked stealth credentials, while Lockheed faced pushback on the F-35.

> "The Air Force needs a contractor dedicated to bringing in the LRS-B on time and on budget."

In the matter of all-aspect stealth, where design is everything, how would Boeing as prime contractor give design authority to a subcontractor? For that matter, why would Lockheed share its stealth fighter design experience with Boeing in the LRS-B program and jeopardize its advantage over Boeing in the next, "sixth-generation" fighter competition?

The lack of stealth bomber experience, the management risks associated with the Boeing/Lockheed team, and the dedication of those companies' resources to other Air Force priorities make them an unwise choice to produce the nation's next long-range strike bomber. Northrop Grumman leads a team with the experience, portfolio, dedication and focus to affordably develop, field and sustain the new stealth bomber. That's why it will win.

THOMPSON

maintenance network. Lockheed Martin has the only productionized low-observable-edge manufacturing capability in the industry, and the most advanced software-generation skills of any aircraft company. Boeing has more expertise than any other company in using advanced composites to manufacture large aircraft.

Northrop Grumman has nothing like this. Its main aircraft facility in Palmdale, California, is engaged in building UAS, modifying existing airframes and turning out subassemblies. Because it is not engaged in high-rate production of finished aircraft, Northrop Grumman does not have the articulated supply chain or cost-control systems developed over many decades by its competitors. It also lacks the kind of risk-management skills for which Lockheed's Skunk Works has become famous.

> "Boeing and Lockheed Martin are far better equipped to deal with any changes in Air Force bomber plans."

Financial resources. Boeing and Lockheed Martin together generated $136 billion in revenues last year. Northrop Grumman generated $24 billion, marking its fourth straight year of shrinking sales. The huge disparity in revenues—over 500%—between the two teams means Boeing and Lockheed Martin are far better equipped to deal with any changes in Air Force bomber plans. When Boeing was faced with a demanding Air Force customer in the second round of competition for the KC-46 tanker, it doubled down; Northrop Grumman pulled out, citing potential risks to its bottom line.

Past performance. Northrop Grumman cites its experience in building the B-2 bomber as a prime qualification, neglecting to mention that it features antiquated technology and is an upkeep nightmare (18 hr. of low-observables maintenance for every hour of flight). It also neglects to mention that at the height of production, B-2 was Boeing's biggest defense program, employing 10,000 people; Boeing built the B-2's outboard wing, aft center fuselage, landing gear, fuel system and weapons delivery system. Boeing then went on to work with Lockheed Martin on the first fifth-generation fighter, the F-22, which was a more advanced aircraft.

The Long Range Strike Bomber will be more capable than the B-2 in nearly every measure, including stealth. It will satisfy key performance parameters largely by adapting mature technologies and processes from other aircraft that Boeing and Lockheed Martin developed. Because Northrop Grumman has not been as intimately engaged in developing stealth or software for the F-35, or pioneering composite production techniques for large aircraft, it would have to play catchup in a wide range of skills.

The conclusion is obvious: Boeing and Lockheed Martin comprise the most qualified team to develop a new bomber, and selecting Northrop Grumman would entail a far higher level of risk.

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June 17—Commercial Aerospace Manufacturing Briefing, Paris.
Oct. 13-15—MRO Europe, London.
Nov. 3-5—MRO Asia, Singapore.
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May 26-29—Eighth Chaos Conference at Henri Poincare Institute, Paris. See www.cmsim.org
June 1-5—University of Kansas Aerospace Short Course Program. Overland Park, Kansas. Also **June 15-19** in Montreal. Plus **Sept. 14-25** in San Diego. And **Nov. 16-20** in Orlando, Florida. See www.aeroshortcourses.ku.edu
June 4—Aerospace Today . . . and Tomorrow—An Executive Symposium. Williamsburg, Virginia. See www.aiaa.org/ATT2015
June 22-26—American Institute of Aeronautics and Astronautics (AIAA) Forum and Exposition. Dallas. See www.aiaa-aviation.org
June 27-29—AIAA Propulsion and Energy Forum and Exposition (Space 2015). Pasadena, California. See www.aiaa-space.org
July 7-9—Fourth International Space Station Research and Development Conference. Boston Marriott Copley Place. See www.issconference.org
Aug. 31-Sept. 2—Airports Council International Latin America-Caribbean World Annual General Assembly 2015. Panama City. See www.aci-waga2015.com
Aug. 31-Sept. 2—AIAA Space and Astronautics Forum and Exposition (Space 2015), Pasadena, California. See www.aiaa-space.org
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Why Northrop Grumman Will Win the Bomber Competition

BY ROBERT HAFFA

The U.S. Air Force soon will select a prime contractor to develop and build its stealthy Long-Range Strike Bomber (LRS-B), an aircraft critical to ensuring the nation's capability to project military power at any time, and at any place. On the surface, industry analysts have characterized the competition between the team of Boeing-Lockheed Martin and the one led by Northrop Grumman as a toss-up. However, a deeper dive into Air Force requirements and the teams' capabilities establishes Northrop Grumman as an overwhelming favorite to produce the LRS-B. Here's why:

The ability to focus and prioritize. Owing to the missteps characterizing the acquisition of the F-35 fighter and KC-46 tanker, the Air Force needs to be assured of a prime contractor willing to focus its attention, resources and advocacy on the new bomber. However, the Boeing/Lockheed Martin team is overwhelmed with trying to fix other Air Force priority programs. Boeing finds its military business distracted by a surprisingly painful tanker program, while Lockheed Martin is consumed by F-35 delays and substandard performance. Consequently, an LRS-B in development would be seen as a lower priority for the Boeing-Lockheed team when the KC-46 and F-35 are in their production phases, finally generating profits.

Recent history supports this contention. When the Air Force push for more F-22s threatened F-35 revenues, Lockheed Martin's support for the F-22 quickly evaporated. Similarly, it is improbable that Lockheed would give up some F-35s or Boeing would slow the KC-46 line to keep the LRS-B on track—making the LRS-B a billpayer for those troubled programs. In contrast, Northrop Grumman is focused on the bomber and positioned to deliver on time and on budget.

The relevant experience needed to deliver. The Air Force procurement chief testified to Congress that the cap on the cost of each bomber previously established—$550 million per aircraft in 2010 dollars—will be retained in this competition. Northrop Grumman is the only company to develop, build, field and sustain a stealthy, long-range strike aircraft—the B-2 bomber. That experience of re-

Robert Haffa, a retired U.S. Air Force colonel, is the former director of the Northrop Grumman Analysis Center.

Boeing-Lockheed Is the Low-Risk Bomber Team

BY LOREN THOMPSON

The U.S. Air Force has said little in public about the performance requirements for the Long-Range Strike Bomber, and the two industry teams vying for the contract are mum about their proposals. There's no way an outsider can evaluate which offering has greater merit. However, it is feasible to assess which team is more qualified to execute the program.

So let's assume we are a source-selection authority charged with selecting not a bomber, but a bomber team. The choice is between a group led by Boeing on which Lockheed Martin is the primary teammate, and one led by Northrop Grumman. Which team is most qualified, based on relevant experience, current capabilities, financial resources and performance?

Relevant experience. During the last three decades, Boeing and Lockheed Martin together have been lead integrators for 95% of the Air Force's bomber and strike aircraft, including such well-known airframes as the F-15, F-16, F-22 and F-35 fighters, and the B-1 bomber. Between the two of them, the companies have delivered more than 3,000 aircraft to the service since 1980. They continue to be the lead suppliers of fixed-wing aircraft to the joint force today, delivering over 300 fighters, airlifters and reconnaissance planes in 2014 alone.

By comparison, Northrop Grumman has been a relatively minor player. In recent years, Northrop Grumman has delivered fewer than 10 fixed-wing airframes per year to customers, typically manned turboprops and the Global Hawk unmanned aerial system (UAS). Its main role in military aviation today is building subassemblies for aircraft integrated by Boeing and Lockheed Martin.

Current capabilities. Boeing operates production lines for fighters in St. Louis and for large military aircraft such as the P-8A Poseidon in the Seattle area. It also is the world's biggest producer of commercial transports. Lockheed Martin operates the only fifth-generation fighter line in the world, at Fort Worth, turning out the triservice F-35 fighter—an aircraft derived in part from the Boeing-Lockheed collaboration on the Air Force's F-22 air-superiority fighter.

This high level of ongoing activity enables the two companies to sustain a huge workforce of engineers and technical specialists, a global supply chain and a sprawling

Loren Thompson is chief operating officer of the Lexington Institute, which receives money from Boeing and Lockheed Martin.

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