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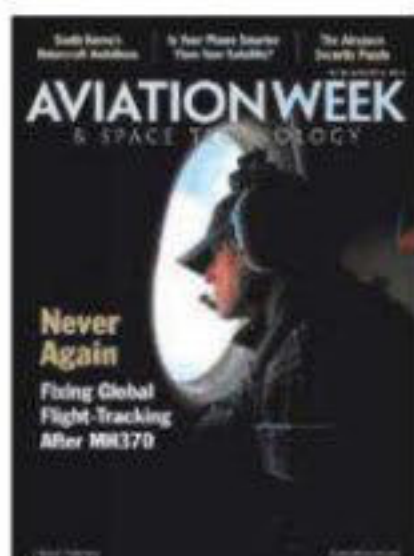
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DEFENSE



IN THE COVER

In the wake of a Malaysia Airlines Boeing 777 vanishing, aviation is working to make global flight-tracking a reality. A special report beginning on [page 38](#) explains the technologies and details the latest work. In our cover photo, Michael Makin, a flight engineer warrant officer for the Royal Australian Air Force, searches for signs of MH370 in a Lockheed AP-3C Orion as part of Operation Southern Indian Ocean. The massive search spawned calls to overhaul how airlines and air navigation service providers track aircraft on oceanic routes. Royal Australian Air Force photo.



49 Terrestrial smartphone technology is finding its way back into space in the burgeoning small-sat movement.



22 South Korea gives its indigenous aircraft industry a chance by selecting KAI to develop a civil/military helicopter.



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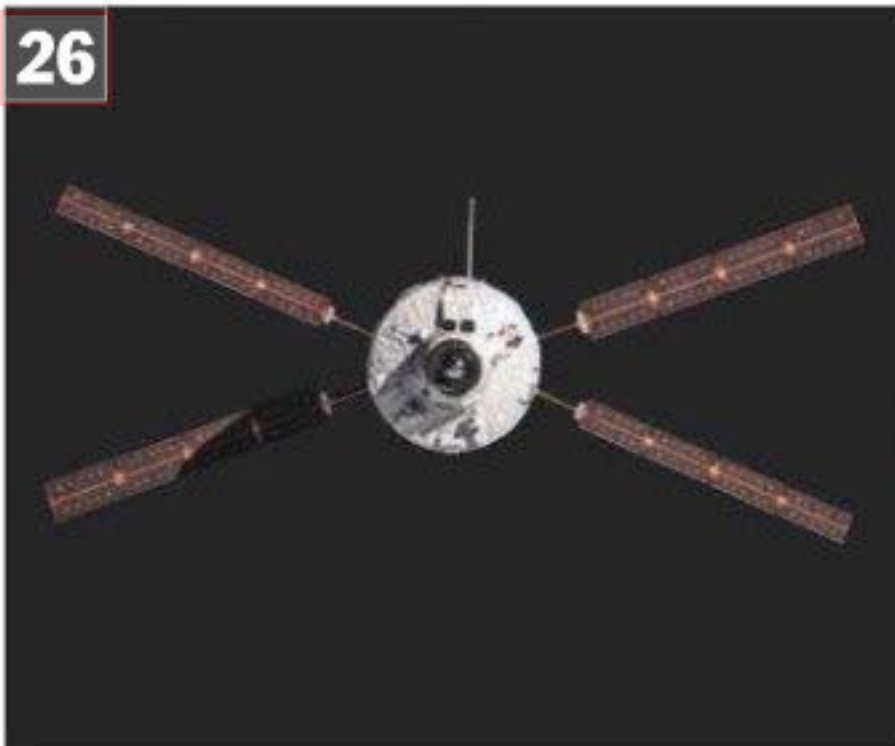
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A roundup of what you're reading on AviationWeek.com

Our team was on the ground and in the air at **the Experimental Aircraft Association's annual AirVenture in Oshkosh, Wisconsin**. Read our coverage beginning on [page 34](#), then click over to our online show page to read articles and blog posts and **see more than 100 photos**. AviationWeek.com/Oshkosh

FIXING FLIGHT-TRACKING

Read our cover package beginning on [page 38](#), then listen as Avionics & Safety Editor John Croft, Executive Editor Jim Mathews and *Air Transport World's* Aaron Karp **discuss what is needed to overcome the challenges of global flight-tracking**, in our latest Check 6 podcast. AviationWeek.com/Podcast

MEDIA MATTERS

Senior International Defense Editor Bill Sweetman was **asked by CNN** to talk about protecting commercial aircraft in the wake of the shutdown of Malaysia Airlines Flight 17, **but much of his level-headed analysis did not make it into the piece the network put together**. Read his recap or the process and his frustrations (ow.ly/zNgvw). AviationWeek.com/Ares

READER COMMENT

Reacting to our online article "Boeing Urges International Action To Meet Pilot Shortage Challenge," 'Inspector' wrote: **"What comes next? Crisis, of course, a well-managed one that allows the remaining behemoth airlines to hire pilots with less experience and qualifications, train them less and work them harder. Congress and the FAA just need to bend a little on safety rules the airlines have been fighting for decades."** ow.ly/zNhom



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“The Boeing 747-8F is an exceptional aircraft and a stair-step improvement in freighter technology. Ours are delivering enhanced revenue payloads and operating efficiencies for our customers and driving growth in our core ACMI business.”

—William J. Flynn, President and Chief Executive Officer, Atlas Air Worldwide
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Letters should be shorter than 200 words, and you must give a genuine identification, address and daytime telephone number. We will not print anonymous letters, but names will be withheld. We reserve the right to edit letters.

NAI NAYSAYER

I take exception to the commentary "A Fine Mess" by Madhu Unnikrishnan (AW&ST July 21, p. 19). It is a naked endorsement supporting Norwegian Air International's (NAI) attempt to serve the U.S. An opposing opinion should receive equal weight.

If NAI intends to register its airline in Ireland and hire aircrew and flight attendants in Asia, that should be a non-starter for U.S. passengers. Outsourcing jobs to low-cost, subpar-skilled pilots is no way to run an airline. Note the recent number of airline accidents caused by personnel who do not seem to possess the requisite airmanship.

Also, the commentary lists or alludes to some supporters of NAI's application who are lobbyists who promote this cause with little regard for passenger safety or industry safeguards.

Capt. William M. Ermolovic
SAN DIEGO, CALIFORNIA

FUEL FOR THOUGHT

Regarding "Malaysian 777 Shoot-down—Another Big Blow" (AW&ST July 21, p. 12), even though it is well known that surface-to-air missiles emit a white exhaust plume during launch and climb, I have read of no reports of such a plume being witnessed. Is it possible the Russians have developed a stealth combustion propulsion fuel?

Scott Majury
MERCER ISLAND, WASHINGTON

BREACHED BRANCH

Unmanned aerial vehicle developers seek to dispel the public's fear of rogue machines by insisting there will always be a human in the "kill chain." However, in "Stealth by Routine?" (AW&ST July 21, p. 29) the work being described—enabling the Taranis UAV to operate when deprived of data links—amounts to giving it autonomous capability.

The difference between asking or not asking for permission entails nothing more than a branch in the code.
Dan Patterson
MORGAN HILL, CALIFORNIA

REFRACTION AT FAULT?

John Croft's "False Promises" (AW&ST July 21, p. 38), which covers preventing autopilot false glideslope prompts, made me think of the crash of a Gulfstream G-2 into the side of a mountain in Hot Springs, Virginia, on Sept. 26, 1976. I was an air traffic controller at Trenton Mercer Airport in New Jersey, where the aircraft, owned by Johnson & Johnson, departed.

The NTSB report stated: "The National Transportation Safety Board could not determine the probable cause of the aircraft's descent below decision height and impact with terrain 500 ft. below the elevation of the runway."

Whether hand-flown, or on autopilot, the aircraft appeared to fly directly into the mountainside. There had to be an explanation other than pilot error or equipment malfunction.

I developed a theory, based on the extra glidepaths generated by the glideslope transmitter. I believe that one of those glidepaths, or the original, was reflected or refracted by the cloud layer below the normal glidepath. If a normal glidepath was reflected, it would have reversed the signal the aircraft received. A false glidepath could have been refracted, which would have provided the same result.

Either way, a signal would be propagated down the mountain. After quickly flying through the fly-up indication, the fly-down indication would be the strongest signal, especially once the aircraft had descended below runway elevation.

Perhaps a proper physics simulation with various combinations of cloud and moisture would reveal an explanation.
James W. Simpson, Jr.
COCOA, FLORIDA

TWISTS IN THE GLIDEPATH

The article "False Promises" states that glideslope "... characteristics above 3 deg. were previously not generally known."

However, in the early 1970s, as a young Air Force officer assigned to the then-Ground Electronics Engineering Installation Agency Flight Navigation Branch, we performed installation engineering of Air Force instrument landing systems (ILS) throughout the world. We had the only transportable Glideslope Van available for site flight-testing and could deploy anywhere. NASA requested we investigate using an ILS glideslope at Edwards AFB, California, as a possible landing aid for

False Promises

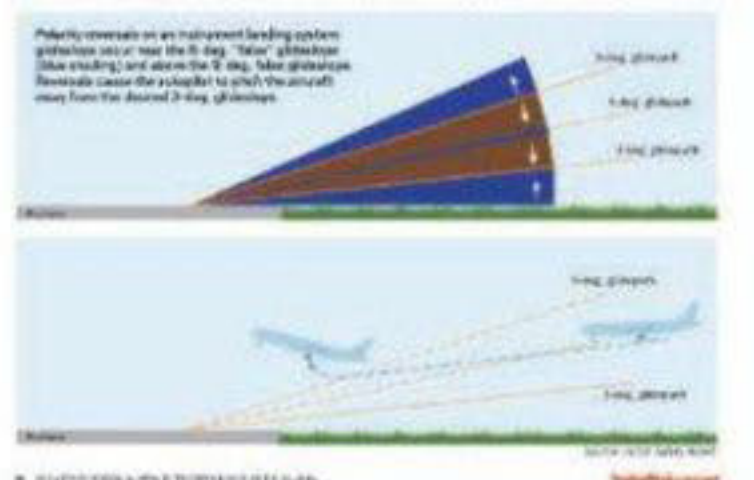
Boeing fix targets 'false glideslope' upsets

John Croft Washington

Boeing is preparing a software update for the 737 MAX 8 to prevent some high speeds when the instrument landing system (ILS) glideslope is lost.

The Boeing 737 MAX 8 is a two-engine aircraft that is being marketed as a "green" aircraft. It is being marketed as a "green" aircraft because it is being marketed as a "green" aircraft. It is being marketed as a "green" aircraft because it is being marketed as a "green" aircraft. It is being marketed as a "green" aircraft because it is being marketed as a "green" aircraft.

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ILS glideslope system. The 3-degree glideslope is shown as a solid line, and the 4-degree glideslope is shown as a dashed line. The diagram is labeled 'ILS glideslope' and '3 deg. glideslope' and '4 deg. glideslope'.

the pending space shuttle.

One of our engineers told me that they flew approaches at angles higher than 3 deg. because the shuttle would use steeper angles than conventional aircraft. He noted that every approach angle that was an even multiple of 3 deg. would provide inverted signals. Clearly, this characteristic of the glidepath produced by the ILS system was known as far back as the early 1970s. Apparently, these results were never published.

Julian J. Topolski
COLORADO SPRINGS, COLORADO

SOLO JOURNEY

"Out There" and related articles (AW&ST June 23, pp. 38-46) show how NASA and its partners are developing hardware to support an eventual human presence on Mars. But how can the public be inspired to fund a program when the results are so far in the future they won't be seen by many of today's taxpayers?

NASA has been studying how to put humans on Mars since the 1960s, but has abandoned work on critical enabling technologies that would have made the journey much easier. Without nuclear propulsion, an early human presence on Mars hinges on the concept of a one-way mission, the most feasible first step being a trip with only one astronaut pioneer.

Our space agency refuses to consider that particular colonization option. Fortune favors the bold. Are there no bold thinkers left at NASA?

James C. McLane, 3rd
HOUSTON, TEXAS

Who's Where

Shawn Kling has been named president of *Universal Asset Management*, Memphis, Tennessee. He has been chairman of Gulf Strategic; a member of the boards of directors of Global Energy & Lighting and Red Arrow Logistics; and strategic adviser to Dynamis Energy. **Greg Brinkerhoff** has been appointed chief financial officer. He has been CEO of First Leasing Co. and was senior vice president-finance for Oracle. **Tracy Andrews** has been promoted to senior vice president from vice president-operations. **Craig Richardson** has become vice president-strategic markets. He was head of aviation sales and marketing for InSync UK Ltd.

Carl Trustee (see photo) has been appointed as vice president of Landing Systems Solutions for the Aerospace Group of *Crane Aerospace & Electronics*, Lynnwood, Washington. He was head of the Central Engineering Group at Parker Aerospace.

Don Casey has been promoted to

senior vice president from vice president-revenue management for *American Airlines*.

Jonathan Archer has become director of engineering and airworthiness for the Washington-based *General Aviation Manufacturers Association*. He was an associate with Booz and Co., working on projects for the FAA and Joint Planning and Development Office.

Johann Panier (see photo) has been named CEO of U.S.-based *Barfield Inc.*, which Air France Industries KLM Engineering & Maintenance recently acquired. He was head of business development for AFI KLM E&M.

USN Rear Adm. **Jesse A. Wilson, Jr.**, has become director of the *Joint Integrated Air and Missile Defense Organization on the Joint Staff*, succeeding USAF Brig. Gen. **Kenneth E.**



Carl Trustee



Johann Panier



Mark A. Caylor



Stephen C. Movius

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.

Todorov. Wilson was executive assistant to the chief of naval operations and interim deputy director of the 21st Century Sailor Office.

Mark A. Caylor (see photos) has been named corporate vice president/president of Enterprise Services/chief strategy officer and **Stephen C. Movius** corporate vice president/treasurer of Falls Church, Virginia-based *Northrop Grumman Corp.* Caylor adds the chief strategy officer role. Movius continues as vice president-investor relations. ☼

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DEFENSE

Assembly Starts for Last C-17

Boeing has completed the main wing spar of the 279th and final C-17, marking the start of assembly for the last military airlifter to be made at its Long Beach, California, facility. The aircraft, which will be completed with the shut-down of the line in 2015, is one of 10 still unsold. Boeing says it is confident of placing all 10 by the end of the year with unspecified customers in the Middle East and possibly elsewhere. Other potential takers include India, which received its sixth C-17 on July 28. The Indian air force has 10 C-17s on firm order. Boeing is expected to complete delivery of the entire original order by December 2014. The first of India's C-17s touched down there in June 2013.

AIR TRANSPORT

Charleston Gets 787-10

Boeing will assemble the 787-10, the third and longest 787 derivative, exclusively at its Charleston, South Carolina, facility, making it the first of any Boeing commercial model to be completed away from the U.S. West Coast. The decision was widely expected, since the 110-ft. midbody section of the 787-10 will be 10 ft. longer than that of the 787-9, making it marginally too long to be transported in the fleet of specially converted 747-400 Large Cargo Freighters that form the backbone of the logistics network that ferries parts to the assembly lines in Everett, Washington, and South Carolina. "We looked at all our options and found the most efficient and effective solution is to build the 787-10 at Boeing South Carolina," says 787 Vice President and General Manager Larry Loftis. The 787-10 will be 224 ft. long when assembled, compared to 206 ft. for the recently developed 787-9 and the 186 ft. for the 787-8. The 787 line in South Carolina is set to increase production to five per month in 2016 from the current rate of three. The 787-10 will be introduced onto the line in 2017 as part of the plan to increase the production rate at Charleston to seven per month by 2019-20. By then, Boeing plans to be producing seven 787-8s and 787-9s in Everett per month on a single line, for a total of 14 a month between the two sites. Boeing has orders for 132 787-10s, the first of which is scheduled for delivery in 2018.

**Aero Vodochody Relaunching L-39**

With about 3,000 built, and around 400 still in operation around the world, the L-39 Albatros jet trainer was a major success for Czech manufacturer Aero Vodochody.

But since the breakup of the Warsaw Pact, the manufacturer has struggled to emulate the L-39's success, with attempts to offer an upgraded L-159 version as a light strike aircraft resulting only in a sale to the home nation and a number of unsuccessful export attempts.

But now the company is planning to offer a new version of the L-39, based around an upgraded engine and avionics that could meet the need for a lower-cost training aircraft like Alenia Aermacchi's M-346 and the BAE Hawk, but provide the jet performance that the latest range of turboprop trainers struggles to fully emulate.

The L-39NG will be powered by a U.S.-built Williams FJ44 engine that will replace the current Ukrainian-made Ivchenko-Progress AI-25TL, with an eye toward reducing fuel burn and increasing performance and range. The airframe also will be modified, eliminating the need for wingtip fuel tanks and introducing a new avionics suite that will include embedded, simulated weapon training. Aero Vodochody plans to market the aircraft to current operators of the L-39, fly a prototype L-39NG in 2016 and make first deliveries in 2018. Meanwhile, U.S. operator Draken International is buying and refurbishing 28 former Czech air force L-159s for use in supporting military training contracts.

ROTORCRAFT

Tunisia Wants Black Hawks

Tunisia wants to purchase a fleet of heavily armed Sikorsky UH-60 Black Hawk helicopters, as the country modernizes its armed forces. The deal with the North African country could be worth \$700 million, according to the Defense Security Cooperation Agency, which notified the U.S. Congress of the possible program July 23. Tunisia has requested 12 UH-60Ms along with a large quantity of AGM-114 Hellfire missiles, 2.75-in. Hydra unguided rockets and the integration work that could turn some of those unguided weapons into guided ones. The Tunisian armed forces currently operate an aging helicopter fleet of Bell UH-1s and Model 412s, as well as French-built Aerospatiale Alouettes and Gazelles. Last year, the air force began to replace older C-130B Hercules airlifters with the more modern C-130Js. If the Black

Hawk deal goes ahead, it would make Tunisia the second operator of the UH-60M in Africa after Egypt.

Italy Ends Corruption Probe

Italian prosecutors have ended their investigations into alleged corruption surrounding the sale of 12 AW101 VIP helicopters to the Indian air force in 2010. AgustaWestland has agreed with the tribunal in Busto Arsizio to pay what the company describes as a "negligible fine" to settle the case, but insists the fine is not an admission of any wrongdoing. Finmeccanica, AgustaWestland's parent company, is keen to put the 18-month-old scandal behind it so it can continue with reorganization of the group, led by CEO Mauro Moretti. However, Indian authorities are continuing with their investigation, led by the country's Central Bureau of Investigation. The Indian government terminated the €560 million (\$754 million) contract



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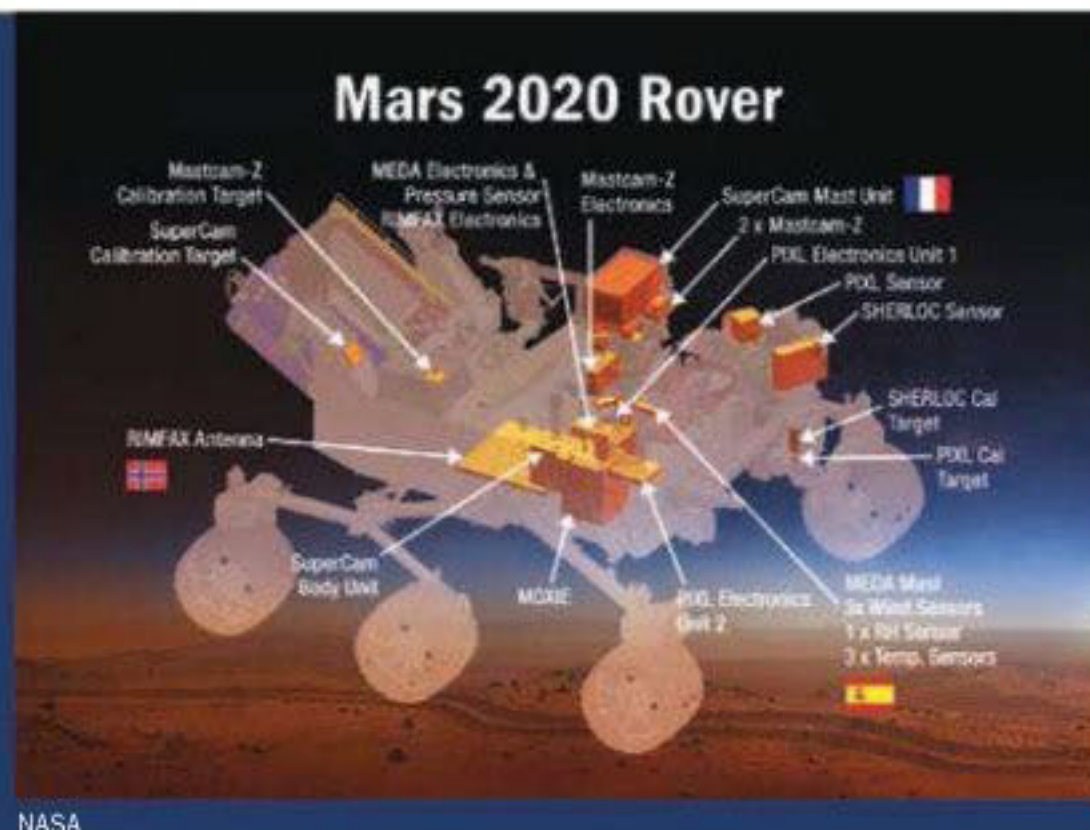
Coring and Caching

Planetary scientists hope the seven instruments NASA has competitively selected for its planned Mars 2020 rover will find evidence that life has existed on the red planet and maybe that it still does.

In addition to providing a contextual step up from the "bulk" composition data that Curiosity's internal chemistry lab obtains from surface samples, the new rover is planned to be able to drill into rocks as far as 10 cm for pristine material, including organics undamaged by radiation and ultraviolet light, and to cache promising samples for state-of-the-art laboratory analysis on Earth. It also will include the first in-situ resource utilization experiment on another planet.

Dubbed "Moxie," the system is designed to produce oxygen from the planet's carbon-dioxide atmosphere as an enabler for human exploration. Engineers hope Moxie will determine "can we actually generate the oxygen, what kind of rates can we generate it at, what kind of efficiency can we do," says William Gerstenmaier, associate NASA administrator for human exploration and operations. "And that affects mission design."

The other six instruments selected are: Mastcam-Z, an advanced stereoscopic camera that can zoom in for greater detail; SuperCam,



NASA

an upgrade of Curiosity's ChemCam that will use lasers to vaporize bits of rock for chemical and mineralogical analysis, including detection of organic compounds; Planetary Instrument for X-ray Lithochemistry, an X-ray fluorescence spectrometer that will provide the most detailed chemical analysis yet of surface materials; Scanning Habitable Environments with Raman & Luminescence or Organics and Chemicals, which will use an ultraviolet laser to complement the mineralogy and organics detection of

the other instruments; the Radar Imager for Mars Subsurface Exploration, a ground-penetrating radar with a range of 0.5 km that will allow scientists to link surface outcrops; and the Mars Environmental Dynamics Analyzer, a weather station and dust monitor.

Michael Meyer, lead scientist for NASA's Mars exploration program, says in general the instruments in the \$130 million suite were selected to complement the others' findings. Still in development, the caching system would enable the eventual use of mass spectrometers and other laboratory gear too large to send to Mars for the more conclusive analysis that makes Mars sample return the top priority of planetary scientists polled in the National Academies of Science decadal survey.

for the 12 VIP helicopters in January, after the corruption scandal emerged in March 2013 with the arrest by Italian officials of then-Finmeccanica Chairman Giuseppe Orsi, who secured the Indian deal when he was CEO of AgustaWestland.

First EC145 T2 Delivered

Airbus Helicopters handed over the first example of its new EC145 T2 light twin-engine helicopter to German air ambulance operator DRF Luftrettung in Donauwörth on July 31. The T2 features new engines, new avionics and a new

Fenestron shrouded tailrotor, replacing the traditional two-blade anti-torque system on the EC145. Production of the standard EC145 will continue into next year, and Airbus will still produce kits for its plant in Mississippi so it can build the UH-72 Lakota for the U.S. Army.

'Neighborhood Watch' in Space

The first two of four U.S. Air Force Geosynchronous Space Situational Awareness Program (GSSAP) satellites—developed under contract with Orbital Sciences Corp. in secret—are now operating in "near geosynchronous" orbit (GEO) as a "neighborhood watch."

"They will be on the lookout for nefarious capability other nations might try to place in the critical orbital regime," where some of the most precious military satellites operate, says Gen. William Shelton, outgoing Air Force Space Command chief. Those spacecraft include the Space-Based Infrared System early missile warning spacecraft, Mobile User Objective System and Advanced Extremely High Frequency communications satellites.

The GSSAP satellites were developed under contract with Orbital Sciences Corp. in secret; their existence was revealed by Shelton in February in an attempt for the U.S. government to be transparent. However, officials hope that acknowledging the capability of the satellites—designed to spy on other space-

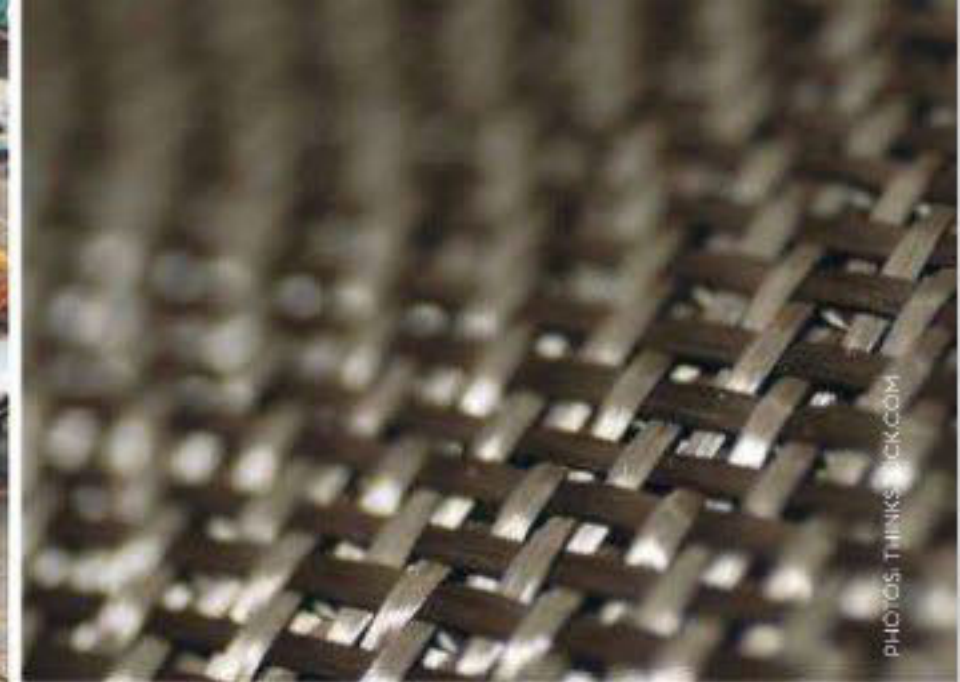


UNITED LAUNCH ALLIANCE

craft—could deter countries that are considering malfeasance with allied assets in their own space operations. The spacecraft also will show rendezvous capabilities in order to use onboard cameras to get the "best possible vantage point for collecting images" of targets in GEO.

The Air Force has not released GSSAP specifications, including payload and weight. Nor has the service released the price to develop and build the satellites. Officials say this is to protect its capabilities. The first pair was lifted into orbit last week by a United Launch Alliance Delta IV. Two more satellites are set for launch in 2016, Air Force officials say.

A third payload, the Air Force Research Laboratory's Automated Navigation and Guidance Experiment for Local Space, also built by Orbital, is designed to conduct experiments for space surveillance techniques by evaluating the area around its host rocket's proximity after separation. The tests will begin about 50 km (31 mi.) from the upper stage and progress to within several kilometers from the target.



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By Byron Callan

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COMMENTARY

New Targets

Defense companies reassess portfolios as global focus grows and war-related demands wane



Defense company earnings reports for the quarter that ended June 30 will not be completed until the end of this week. Reports released already and the subjects of related conference calls, however, underscore three bigger themes that should continue to play out in 2014-15.

This first trend is portfolio reshaping and focus. Earlier this year, U.K. companies Qinetiq and Chemring announced divestitures. This earnings season, Rockwell Collins announced it was selling DataPath, and General Dynamics that it was offloading AxleTech. Both businesses benefited from war-related demand for satcom services and repairs and upgrades to Mine-Resistant Ambush Protected vehicles, respectively, and had seen sales slide as demand waned. Additionally, there have been reports that Finmeccanica is mulling the sale of DRS.

This latest cluster of divestitures is intriguing because all were purchased when U.S. forces in Iraq had peaked and forces in Afghanistan were increasing to plateaus in 2010-11. These moves suggest far less corporate confidence that the U.S. will become involved in another major ground campaign, though arguably those chances were apparent when the properties were acquired.

Defense portfolio reshaping could accelerate in 2014-15. It does not appear to be driven by a need to raise cash to pay down debt or meet other pressing financial obligations. Besides sales of businesses that have been wrung out by post Iraq-Afghanistan drawdowns, there are others factors driving defense managements to reassess their portfolios.

Outcomes of specific defense com-

petitions for combat vehicles, fighter aircraft and naval vessels could provide one trigger as contractors reassess growth prospects in these markets. Competitive pressures in unmanned platforms, space satellites and launchers, and government services are sectors where managements may need to reassess their appetite to invest or substantially alter costs to become more competitive. Those tasks might be better performed by different owners.

Finally there is the issue of focus. General Dynamics noted that AxleTech's defense sales had fallen to the point where commercial revenue was more important and that the company would be better off with a management focused in that direction. Rockwell Collins mentioned the DataPath divestiture as part of a plan to concentrate on "core products." In demanding defense markets, managements need this focus to ensure core businesses can thrive.

A second trend is that while there are plenty of international opportunities, these too have risks that shareholders may not have appreciated. Managements of both Lockheed Martin and Raytheon said international sales targets will be increased. Harris discussed the strength it continues to see in international demand for tactical radios. International has been seen as a good thing by investors, but in the

past quarter some nuances regarding program risk and supply chain emerged that had not been widely appreciated.

In its June quarter, Raytheon reversed some profit it had earlier realized on the Australian Air Warfare Destroyer program due to delays by its partners. Management went out of its way to state this was an isolated incident based on the structure of the contract. Still, analysts asked management questions during the Raytheon and Harris conference calls on international pricing, so there may be more concern that, along with some development risk, global market competition is stiffening.

There also was Raytheon's comment in its conference call that investors should "view us more from a global perspective than just a domestic exporter." This shift has supply-chain implications that could emerge as other U.S. primes seek to become more global. Some companies may benefit from this trend and in Raytheon's case, Mitsubishi Heavy Industries' role in the export of Patriot components (see photo) from Japan to Qatar is a case in point. But other suppliers could lose share as firms seek a global footprint.

A third trend is that managements called out investments they were making to win new defense business and, for the most part, spent less time enumerating cost reductions. Raytheon and Northrop Grumman executives discussed internal technology developments and capital expenditures for centers of excellence, respectively, that they hoped would aim to make their companies more competitive. Harris Chairman and CEO William M. Brown stated that "company funded R&D was up 30% in the fourth quarter and 12% for the year to 5.3% of total revenue, a level significantly higher than peer companies. . . ."

Some of these callouts by management may be in response to Defense Department efforts to encourage contractors to spend more on independent research and development. But some managements are also signaling to investors that through these internal investments, they hope to grow and gain market share. That's a somewhat different message than in 2012-13, when bigger share buybacks and fatter dividend payouts were seen as the way to investors' hearts. ☛

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BAE SYSTEMS

COMMENTARY

A Different God

Stealth rewrites the rules for the aerodynamics team behind the U.K.'s Taranis UCAV

The last time BAE Systems designed and flew a U.K.-funded combat aircraft demonstrator, things were different. The company was called British Aerospace, the aircraft was manned, and aerodynamic performance was king.

First flown in 1986, the Experimental Aircraft Program (EAP) demonstrator was the scion of a line of supersonic combat aircraft reaching back to the English Electric Lightning prototype in 1954 and including the BAC TSR2 in 1964 and multinational Panavia Tornado in 1974. EAP was the precursor to the four-nation Eurofighter Typhoon, which first flew in 1994.

The Taranis unmanned combat air vehicle (UCAV) demonstrator is a distinctly different beast. Where EAP was optimized around the supersonic agility possible with advanced aerodynamics and flight controls, Taranis is designed for low observability (LO) and radar cross-section (RCS) is king.

As France and the U.K. begin to jointly study the feasibility of a Future Combat Air System, Taranis is proof BAE still has the strength in aerodynamics to secure the U.K. a central role in collaborative development of a future unmanned combat aircraft, says chief aerodynamicist Chris Lee, giving the Royal Aeronautical Society's Lanchester Lecture at Bristol University on July 22.

"EAP's aerodynamics were developed by the U.K. and built on BAE's flight control system capability," he says. "[Typhoon] is a direct descendant of EAP. . .

It is easy to lose sight of the role the U.K. played in Eurofighter aerodynamics."

While Typhoon helped sustain BAE's supersonic aerodynamics capability, a new challenge emerged in the early 2000s when the U.K. began looking toward a stealthy unmanned combat aircraft. The result was two small U.K.-funded demonstrator UAVs, Raven and Corax in 2003-05, that gave engineers their first taste of designing for low observability. "The U.K. put in place plans to mitigate the risks and collect data. With the flights of Raven and Corax, a large-scale mission-representative demonstrator became feasible," Lee says.

Up through Typhoon, aerodynamicists enjoyed almost unlimited control over external shape, Lee says. With the advent of stealth, "the radar range equation has come to dominate aircraft design," he notes. "Low-observability requirements continue to be the dominant influence on aerodynamics."

LO design means a tailless aircraft (see photo) that is inherently unstable longitudinally and directionally, with non-linear aerodynamics and severely constrained effectors for stability and control, compromised air supply to the engine and aerodynamic effects from LO treatments. Much about Taranis is

still classified, and Lee says only that BAE took an "innovative approach" to addressing the stability and control characteristics caused by adverse aerodynamics. These include rapid non-linear changes in pitch and yaw with incidence that arise from initial flow breakdown over the stealthy shape.

A serpentine inlet and exhaust hide the Rolls-Royce Adour engine from radar at all lines of sight. Taranis "transgresses all good air intake design paradigms," says Lee. "We let RCS tell us what shape it had to be and use aerodynamics to mitigate the result," which includes unsteady, swirling, separated flow at the engine fan face. A full-scale inlet and engine were static-tested at Rolls. The UCAV's stealthy exhaust posed a further challenge. The high-aspect-ratio rectangular nozzle interacts with the wing control surfaces, Lee says. A dedicated afterbody wind tunnel model was tested to determine the throttle-dependent effects that had to be factored into the flight control laws.

"Aerodynamic performance was not a primary requirement for demonstration. Performance had to be adequate to demonstrate the mission," Lee explains. Flight results were in good agreement with modeling, although drag was less than estimated. Initially Taranis flew with an air data probe, but for later flights this was replaced by a "novel" low-observable conformal air data system. "Results were almost indistinguishable from the boom-on flights," he notes.

Beyond Taranis, the challenge is how to turn what has been demonstrated into an operational military capability with demanding payload and range requirements and a wider envelope in terms of speed and maneuverability, Lee says. He calls for greater investment in sustaining the U.K.'s combat-aircraft aerodynamics capability, with closer collaboration among government, industry and academia.

Lee cites as an example the Flaviir program funded by BAE and government, managed by Cranfield University and involving nine other U.K. universities in developing technologies for a low-cost UAV with no conventional control surfaces. Supersonics is one area of potential collaboration with academia. "Typhoon was 25 years ago. There have to be better ways to do it," he adds. ☛



By Pierre Sparaco

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

COMMENTARY

Airbus's Ascendancy

Success has trumped the severe skepticism that greeted the nascent Airbus and its offerings

Contrary to what most public relations firms recommend, Airbus has chosen to downplay the debut of the A320neo (New Engine Option). No official ceremony was staged, unlike the presentation—with Hollywood-style hoopla—for the debut of the A320 in 1987. Of course the A320neo is not an all-new commercial transport, but it does mark the first time that the European manufacturer has secured more than 3,000 firm orders for an aircraft—before it even takes to the air.

Since the initial program's launch in 1984, 10,504 A320-series twinjets have been sold, and today the backlog is a record 4,372. An increase in the production rate from 42 to 50 or more per month is being pondered.

The A320 saga holds many lessons, including the need for a severe reality check when it comes to market forecasts.

When the program was greenlighted, the then-consortium's top executives estimated they could expect to sell up to 800 A320s over 20 years and, based on stable U.S.-dollar/French-franc exchange rates, determined the financial break-even point could be reached with delivery of the 600th aircraft.

In those days, Airbus's market share was nearly nonexistent—the A300B/A310 combined production rate was no more than 40-50 aircraft per year. This new European player (Airbus was established in January 1970) was severely hobbled by the absence of a product range; clearly a quick decision was needed to expand its limited offer.

However, the founding partners, France and Germany, disagreed about how to proceed. Germany insisted Airbus should develop a 230-seat, four-engine long-range jet, provisionally dubbed TA11 (TA for Twin Aisle) in an



AIRBUS/H. GOUSSE

effort to demonstrate Europe's ability to establish itself in a market dominated by Boeing, Douglas and Lockheed. In Bonn, politicians were convinced an aircraft manufacturer must have a long-range offering to be a major player.

France, on the other hand, favored the 150-seat, short-to-medium-haul A320, despite robust sales of the Boeing 737 and Douglas DC-9 and the Boeing 727 trijet's excellent reputation. Then came a battle of market forecasts.

Boeing claimed there would not be sufficient room to accommodate a European player, Airbus responded that its aircraft would demonstrate significantly lower direct operating costs. But could airlines and competitors really believe the Europeans' assertions in light of the modest results? In 1983, the year before the A320's launch, Airbus

sold no more than eight A300Bs and A310s but had also received cancellations covering eight aircraft. By the end of the year, 24 "white tails" were parked at the Toulouse airport.

In other words, the Airbus pioneers needed to step up their game in order to convince governments to fund the envisioned A320. The British, who had in the interim joined the consortium, were reluctant. Prime Minister Margaret Thatcher feared the U.K. would be heading toward another Concorde-type financial morass; Rolls-Royce did not even offer a candidate to power the new aircraft.

Eventually the decision was made to proceed with the A320 based on new concepts and advanced technology such as electronic flight controls, an electronically protected flight envelope, an upgraded man/machine interface and

The first A320neo will fly in a few weeks. Many consider this Airbus's most impressive success to date.

a choice of two engine types—Snecma/General Electric CFM56 and International Aero Engines V2500.

Competition included the CFM56-powered 737-300, new DC-9 derivatives and the envisioned Fokker F-XXX. Not surprisingly, sales remained sluggish. Moreover, no agreement with a U.S. industrial partner could be forged and an attempt to take Canada on board failed (de Havilland of Canada was invited to join Airbus as an associated member and produce 10% of the aircraft).

Roger Beteille, Airbus's then-managing director; outgoing Chief Executive Bernard Lathiere and program manager John Macadam were incredibly optimistic and they proved to be right. However, as U.S. author John Newhouse wrote in *The Sporty Game*, the French in those days adopted a proprietary stance that took awhile to fade. A year after the program's launch, Jean Pierson succeeded Lathiere and proclaimed that Airbus would, in the years to come, gradually achieve a 30% share in the commercial transport market—a pronouncement that was greeted with skepticism from many quarters.

The end result speaks for itself and should be lauded. 🌟



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COMMENTARY

Low-Cost Drawbacks

Airspace, skills shortages are obstacles to Chinese budget operations



AIRBUS/P. PIGEYRE

For about a decade after the low-cost airline revolution began to sweep across Southeast Asia, the Civil Aviation Administration of China (CAAC) was not interested. Then, a year ago, the industry's overseer quite suddenly began to push the idea.

But not everything in China is as choreographed as is often imagined—certainly not commercial aviation, even though the state has controlling holdings across the great bulk of the industry. Some airlines are responding faster to the CAAC's call for no-frills flying than others. And those others may have good reasons for holding back.

Of the four major airline groups, Hainan Airlines was already converting subsidiary West Air to budget operations when the CAAC began its push, while China Eastern was planning to learn the ropes by setting up a Jetstar-branded airline in Hong Kong with Qantas. As Hainan and China Eastern progress with their plans, China Southern is making only a small move while Air China remains aloof, with notions that are not close to execution.

The small private carrier Juneyao is paying heed to officialdom. The government does not own it, but Juneyao, small and lacking the influence and network strength of the big groups, has good reason to exploit policy changes that offer opportunities for growth. The Shanghai airline is not

following the CAAC's recommendation that all private carriers convert themselves to low-cost mode, but it is setting up a budget subsidiary in Guangzhou.

The lack of enthusiasm China Southern and especially Air China are showing for budget operations does not necessarily mean that those two carriers—China's largest and second-largest—suffer from hidebound and unadventurous management. All over the world big airlines with budget affiliates remain a minority. Running one airline is hard enough; running a second adds headaches.

Further, budget aviation in China faces many of the same problems as regional aviation. The scarcity of runway slots at major airports, airspace along important routes, and skilled personnel all over the country are all strong reasons for maximizing revenue in each aircraft. These problems can be solved with time, but for the moment they are so serious that they not only undermine sales of regional jets and turboprops; they are supporting demand for Airbus A330-300s at the expense of standard narrowbodies. In that environment, it cannot be appeal-

ing to allocate precious resources to services that are specifically designed to generate lower fares.

And that makes one of the forthcoming Chinese budget airlines all the more surprising. Hainan Airlines affiliate Capital Airlines plans to convert to low-cost mode, exploiting its runway slots at congested Beijing Capital International Airport to position itself as the strongest budget carrier there. A critic might argue that the best way to exploit runway slots at Beijing Capital would be to allocate them to Hainan Airlines' A330s, which would have more seats and more revenue per seat.

So the reluctance of Beijing-based Air China to set up a budget subsidiary is not so hard to understand. The carrier has announced no plans, but industry officials say it has two, apparently not firm. One is to convert a subsidiary to budget operations, as other big carriers are doing. The other is to set up a low-cost carrier when Beijing opens a new airport, which is not likely before 2019. The new airport may create enough extra capacity to justify taking slots away from the full-service network.

The converted offshoot could conceivably be Dalian Airlines, set up in partnership with the northeastern city of the same name. It is quite small, with only six Boeing 737-800s, but it could be built up. The local government shareholder may not be keen on losing the business-class cabin, however.

Another possibility is Air China's business jet operator, Beijing Airlines, which could seek permission to run scheduled services, quite possibly from the new airport. There is a precedent for such a conversion: Capital Airlines is the scheduled-service branch of business-aviation company Deer Jet.

Shanghai-based China Eastern is eyeing the Beijing budget market, but its local subsidiary, China United, is based at Beijing Nanyuan airport, a relatively quiet field south of the city. China Southern is avoiding that problem altogether: Its first baby step toward a low-cost model is to take out the business-class cabin in some aircraft of subsidiary Chongqing Airlines, based at the big southwestern city of that name. ☞



By Frank Moring, Jr.

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COMMENTARY

Market Opportunity

Rides to orbit lagging smallsat development

Entrepreneurs, listen up. There is money to be made meeting a new need in the spacecraft industry. Engineering schools and their commercial spin-offs are cranking out small satellites at a record pace, but the space launch industry is not keeping up with the hardware necessary to lift them to space. One big advantage of cubesats and other microsatellites is their ability to cut launch costs by hitching rides as secondary payloads. But those rides are not always there.



NASA/BILL INGALLS

SpaceWorks Enterprises, an Atlanta-based engineering outfit, estimates a requirement for more than 400 nano- and microsatellite launches a year beginning in 2020, and finds that the number of satellites needing rides already is growing dramatically. Yet the launches available for satellites of 1-50 kg (2.2-110 lb.) has remained constant, and well below the anticipated figure.

"In order to foster the dynamic growth observed in 2013, the launch vehicle market will need to provide more launches and increase the portion of launches servicing nano/microsatellites," SpaceWorks says in its market report on the tiny spacecraft for 2013.

Overall, the company predicts 2,000 to 2,750 nano- and microsatellites will require launches through 2020. And the problem is not limited to finding a ride. Because technology updates for small spacecraft occur so rapidly given the use of consumer electronics and other off-the-shelf components (see [page 49](#)), launch delays can be a killer.

"When we build a satellite at Planet Labs and it sits on the shelf for six months, that's really old," says Mike Safyan, senior compliance and operations engineer at the San Francisco-based Earth-observation startup. "It's the same thing—you wouldn't want a

smartphone that's six months old."

Launch delays are commonplace. In 2013, SpaceWorks found that 40% of the 82 worldwide launch attempts were delayed an average of 115 days; most were attributable to the launch vehicle. Safyan and his colleagues have learned that the hard way.

"The first launch was supposed to be on an Antares, and that launch got delayed about a year and a half," he says. "It was just really hard to get access to space."

Since then Planet Labs has launched 71 of its "Dove" spacecraft. It just sent 28 of them on another Antares headed for the International Space Station (ISS) (see photo)—the second "flock" of the tiny birds to reach orbit via that route—and in June it sent 11 more to orbit on a Russian Dnepr. Several already have reentered from the relatively low ISS orbit, but Planet Labs is building so many Doves that it considers low Earth orbit an engineering testbed.

"The space station is just one way we get our satellites to orbit," says Safyan. "[W]e take kind of a capabilities-driven approach: What is the launch industry available to us today? If you start putting up a constellation like that, the ISS is one excellent path, but there are other ones. So we [look at] a lot of options. Eventually they average out."

Although SpaceX has lofted cubesats from dispensers attached to the second stage of its Falcon 9 launch vehicle during Dragon missions to the ISS, most small satellites launched as secondary payloads on ISS resupply ride inside pressurized vehicles and enter the vacuum of space via the airlock in Japan's Kibo module. NanoRacks, the pioneering commercial supplier of ISS accommodation services, has developed special "sleeves" to carry the nano-satellites from the pad to its satellite dispenser at the end of the Japanese robotic arm outside Kibo, which jettisons them into orbit.

The Japanese Aerospace Exploration Agency also has a Small Satellite Orbital Deployer that has launched cubesats from the Kibo "porch." Beyond that, SpaceWorks found, there is much unused launch capacity that could handle tiny spacecraft with the addition of deployment hardware.

"The number of launches per year has remained relatively constant over the last four years (2010-13), with an average of 80 attempts per year," the company reported in its 2013 global launch vehicle assessment. "Similarly, the quantity of launches servicing nano/microsatellites has remained constant with 11 launches in 2013, one less than 2012."

Of the 46 launches to low Earth orbit in 2013, excluding human missions on Russia's Soyuz capsules and the Chinese Shenzhou 10 flight, 88% had no space available for cubesats and microsatellites. Yet more than half (47) of the 82 total space launch attempts in 2013 had excess lift capacity that could have been used to orbit nano- and microsatellites, SpaceWorks found.

"Though many launches require the vehicle's full capacity, frequently vehicles launch with excess payload mass capacity," the report states. The problem of launch vehicle underutilization is actually one of "integration slot efficiency" rather than simple mass capacity, according to the report, since secondary payloads need accommodation hardware such as secondary payload adapters and cubesat dispensers.

"There was little excess capacity for nano/microsatellites (1-50 kg) on 2013 launches given vehicle integration limitations," SpaceWorks says. ☛



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COMMENTARY

Another Wrinkle

Boeing's Ex-Im struggles grow, with suspension of deals with Russia

The commercial aircraft industry has largely stayed on the sidelines of the political tension between Russia and the West, but that may be changing. The latest round of sanctions imposed after the shoot-down of Malaysia Airlines Flight 17 includes the suspension of Ex-Im Bank deals with Russia—a decision that could hurt Boeing's commercial aircraft sales there.

Since the end of the Cold War, Boeing has been increasing its partnerships with Russia. From 1991 to 2013, Boeing "completed contracts" in Russia and former states of the Soviet Union worth \$7.5 billion. The company also buys titanium from Russia and plans to invest billions in design and engineering services there. And Boeing also benefits from Ex-Im Bank financing for Russian companies.

In November 2012, the bank helped provide \$497 million in assistance to Russia's VEB Leasing JSC—a bank sanctioned by the U.S. earlier this month—for the sale of Boeing commercial aircraft. Boeing is still evaluating the effects of last week's Ex-Im Bank suspension. "We are aware of the new sanctions just announced by the U.S./EU, and are reviewing the matter to understand what impact, if any, there may be to our ongoing business and partnerships in the region," the company states in an email.

Less clear is whether Airbus will face a similar hit from European export credit agencies. Britain's *The Guardian* newspaper reports that U.K. Export Finance aided a \$50 million deal for Airbus aircraft through VEB Leasing. The French export credit agency Coface has also helped provide financing assistance for

Aeroflot to purchase Airbus aircraft. But Boeing, which benefits from Ex-Im Bank loans far beyond the borders

Boeing is still evaluating the effects of the suspension of Ex-Im Bank deals with Russia.



BOEING

of Russia, still has larger problems looming on the horizon. The suspension comes amid an ongoing fight to renew the bank's charter, which expires at the end of September. Congress is at the start of a month-long break, and when lawmakers return, they will have just 11 working days to renew the bank's charter. ☹

OPENING UP?

Two government sensors that may fly in space under the new U.S. Air Force Hosted Payloads Solutions program (see [page 27](#)) are a French-built advanced data-collection system that will receive data from ocean buoys and electronic-tagged marine life, and a Franco-Canadian search-and-rescue satellite-aided tracking system. Both were developed for NASA and the National Oceanic and Atmospheric Administration and both were left without rides to orbit when the joint

civil/military National Polar-orbiting Operational Environmental Satellite System (Npoess) was cancelled in 2010. The White House killed Npoess in part because the various bureaucracies involved were unable to work together effectively. But now even the secretive U.S. intelligence community (IC) may be ready to use hosted payloads to stretch its funding. "It depends on what the mission is," says Janet Nickloy, chair of the Hosted Payload Alliance and vice president of strategy, space and intelligence at Harris Corp. "I think there are some missions that the IC would probably be comfortable in leveraging hosting, and some they would feel are inappropriate." ☹

CARRY ON

Do guitars qualify as carry-on luggage? According to Congress, they should. But as is often the case in Washington, the law hasn't quite caught up with the rules. Though a law was passed two years ago mandating that musical instruments can be safely stowed on commercial flights, the Transportation Department hasn't yet completed the rules to implement the law. This disconnect might have gone unnoticed, if not for an incident involving the folk-rock band Deer Tick. U.S. Airways blocked guitarist John McCauley from boarding a flight from Nashville to Philadelphia, en route to the Newport Folk Festival in Rhode Island.

The band took to Twitter. Then the *Providence Journal* and other news outlets picked up the story. And Rhode Island's senior Senator, Jack Reed (D), wrote Transportation Secretary Anthony Foxx to demand clarity. "We have a lot of great musicians come to Rhode Island for our world-renowned music festivals, and they shouldn't have to deal with arbitrary and conflicting storage policies from one airline to the next," Reed wrote. "There should be clear rules of the road."

Though the situation in Washington remains unresolved, U.S. Airways brought the matter with Deer Tick to a close, refunding the cost of the airline ticket and springing for a train ride. "In the end, it was not so bad!" McCauley tweeted from the @deertickmusic account. ☹

Brazing Symposium 2014

September 23-24, 2014 • Sheraton Wild Horse Pass Resort & Spa • Phoenix, AZ

The Brazing Symposium informs attendees of brazing techniques, applied research and innovations. The Symposium welcomes participants dedicated to theories, experiments, simulations and applied aspects on brazing of parts for high-temp applications.

Attendees will be drawn from a select group of professionals who are influencing the brazing industry. Both delegates and speakers, are invited to participate based on their academic and occupational achievements within the brazing community.

Monday, September 22, 2014

5:00 - Welcome Cocktail Reception
7:00 p.m.

DAY ONE – Tuesday, September 23, 2014

7:45 a.m. Registration & Networking Breakfast

8:15 a.m. **Chairman Welcome Remarks**
Daniel Kay, Brazing Consultant, Kay & Associates

8:30 a.m. **Development and Implementation of Alternative Repair Processes for Reconditioning of Fr7FA+e, 1st Stage Nozzles**
Dr. Warren Miglietti, Technical Expert – Reconditioning, Power Systems Manufacturing, (An Alstom Company)

9:30 a.m. **Application of Thermodynamic Software for Braze Joint Microstructure Prediction**
Don Mittendorf, Materials and Processes Engineering, Honeywell Aerospace

10:45 a.m. **Resistance Microwelding Techniques in Braze Set-Up Operations**
Jay Kapur, GM, Aimtek

11:30 a.m. **Hydrogen Fluoride Cleaning of High Temperature, Super Alloy, Gas Turbine Components**
John Husko, Technical Sales Consultant, Ti-Coating

12:15 p.m. Luncheon

1:30 p.m. **Active Braze Filler Metal Modification and Optimization**
Charles (Chuck) Walker, Principle Member of Technical Staff, Metallurgy & Materials Joining, Sandia National Laboratories

2:15 p.m. Geosef (Joey) Straza, President & CEO, VerTechs Enterprises Inc.

3:15 p.m. **High Temperature Vacuum Brazing Furnace Design**

Stephen Danilak, Applications Engineer, PVT, Inc.

4:15 p.m. Dr. Ray Xu, Senior Specialist – Joining Technology, Rolls-Royce Corporation

5:15 p.m. Closing Remarks for the Day

5:30 - Cocktail Reception

6:30 p.m.

7:30 - Networking Dinner

9:30 p.m.

DAY TWO – Wednesday, September 24, 2014

7:30 a.m. Registration & Networking Breakfast

8:00 a.m. **Opening Remarks**

8:15 a.m. Dr. Stephen Liu, Director of the Center for Welding, Joining & Coatings Research, Professor of Metallurgical and Materials Engineering, Colorado Schools of Mines

9:15 a.m. **Effective Utilization of the Braze Process for Component Repair**

Brian Frazier, Technical Director, AimMRO

10:15 a.m. **Simplifying Certification: Clarifying Misconceptions between Nadcap and AMS 2750E**

Jim Grann, Senior Technical Manager/ International Sales, Ipsen USA

11:15 a.m. Daniel Kay, Brazing Consultant, Kay & Associates

12:30 p.m. Panel Discussion by Board

1:30 p.m. **Chairman Closing Remarks**

Daniel Kay, Brazing Consultant, Kay & Associates

1:40 p.m. Luncheon

3:00 p.m. 2014 Brazing Symposium Concludes

Register today and secure your place! www.aviationweek.com/events

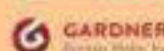
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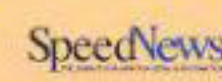
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Rotary Lift

South Korea gives KAI a chance in the global rotary-wing market

Bradley Perrett **Beijing**

In Japan, three companies build helicopters, thanks to government contracts that have been spread among them for more than half a century. The result is that none of them has the single large-scale rotorcraft business that the country could support if it chose just one manufacturer.

South Korea, by accident or design, is avoiding that policy. Its defense and industry ministries have chosen Korea Aerospace Industries (KAI), already the country's most technically advanced rotorcraft maker, as the preferred bidder for a utility helicopter program that may carry the country into the mainstream global market.

Development of the LCH-LAH civil and military utility aircraft will require more than 1 trillion won (\$970 million) in South Korean investment, says KAI, announcing its selection by the industry and defense ministries. The specification calls for a gross weight of about 4.5 metric tons, though there are signs that the result may be closer to 5 tons. A contract to launch the program is due in November. According to Daishin Securities, the cost will be 1.5 trillion won, including a 400 billion won foreign contribution. The budget will surely vary with the choice of foreign development partner, however.

AgustaWestland, Sikorsky, Airbus Helicopters and Bell Helicopter are competing to partner on the program, says KAI. Each has offered existing hardware as the basis of the aircraft; the options range from probably minimal change of the AgustaWestland AW169 to a potentially new helicopter based on the dynamics of the out-of-production, 4.2-ton Bell 430. KAI's request for proposals (RFP) is due this week.

Airbus is proposing its 5-ton EC155, which would need further development. Technically, that must be a highly attractive prospect for KAI and the industry ministry, which is sponsoring the project. There could be similar engineering opportunities with the Sikorsky S-76, which weighs up to 5.3 tons.

The finance ministry, on the other

hand, should smile upon AgustaWestland's contrasting offer of adapting the 4.5-ton AW169. Since the brand-new civil type is still in flight-testing, South Korea would need to pay only for development of a military version; risk would be minimal. But KAI says it, not the government, will choose the foreign partner, even though that decision would affect the size of the public contribution.

A South Korean military requirement for 200 or more helicopters is underpinning the program, whose importance to South Korean industry is little noticed. Amid the seemingly endless twists and turns of South Korea's proposed KF-X fighter program, and efforts to launch a doubtfully viable turboprop airliner or business jet, the

LCH-LAH project offers a real and early opportunity for KAI to enter large-scale, profitable production of a complete aircraft for the international market—or at least a major share in one.

KAI developed the 8.7-ton Surion utility helicopter with much help from Airbus in 2006-13 and has more rotorcraft know-how as a result than rival Korean Airlines, the government's alternative as contractor. KAI also builds AH-64 Apache fuselages for Boeing. Korean Airlines has much more experience in helicopter manufacturing, back to the 1970s, but not in development.

History argues against fragmentation of a national helicopter industry. Westland and Agusta began building U.S. helicopters under license in the late 1940s and early '50s, barely earlier than Kawasaki Heavy Industries. The

British and Italian companies became their nations' rotorcraft specialists, then merged to form an independent powerhouse of the global industry. Kawasaki had to share Japan's orders with Mitsubishi and Fuji—and the Japanese industry still builds mostly foreign helicopters under license.

The LCH-LAH program will proceed first with the Light Civil Helicopter (LCH), development of which should be complete by 2020. The LCH's share of the budget will be 950 billion won, of which 350 billion will come from the government, 400 billion from the foreign partner and 200 billion from KAI and other South Korean companies, says Daishin Securities. It is hard to see how that budget could be used if the AW169 were chosen.

The Light Armed Helicopter (LAH) will follow the LCH in development and be ready for service in 2022. The government will pay the full cost of its development, 600 billion won, says Daishin Securities. That presumably covers the engineering of military variations from the LCH.

This program has evolved from a plan to build a dedicated attack helicopter for the South Korean army. The industry ministry, paying some of the



cost, insisted in 2009 that the aircraft have a passenger cabin instead of the slim two-seat body that would have been ideal for the battlefield. Military effectiveness was thus sacrificed to enlarge the industrial opportunity, even though there would be no opportunity at all without the army's requirement.

The chance for the industry is considerable. Launching the AW169 in 2010, AgustaWestland forecast a market of almost 1,000 aircraft in this category over about 20 years. KAI is targeting domestic sales of 400 units and exports of 600.

The upgraded EC155 would feature an improved drivetrain to increase time between overhauls to the latest standards, says Christoph Zammert, director of Airbus's South Korean helicopter activities. While the gross weight would not change, more power would be needed, he says. The resulting helicopter could look different.

Although its roots go back to the original Dauphin of the 1970s, the EC155 is a heavily revised derivative certified in 1998, with a bigger cabin and a five-blade rotor. The proposed upgrade would not be in the same market as the AW169 because it would be larger and heavier. It would also be significantly smaller

than Airbus's forthcoming X-4, which will be close to 6 tons.

Airbus has offered to stop building the base model if it wins the LCH-LAH competition, KAI Chief Executive Ha Sung-yong tells the *Seoul Economic Daily*. That would mean the EC155 would become an Airbus-KAI product for the global market.

The S-76 is about as big as the EC155 and could offer a similar basis for an upgrade, but Sikorsky, noncommittal about the program, may not be thinking of big changes. "The LAH-LCH program is an ambitious campaign that could be best served using the low-risk and proven capabilities of our S-76 helicopter platform," says a spokesman. "Following the receipt of the RFP from KAI, Sikorsky will determine whether it can participate in this program."

Conceivably, AgustaWestland could offer KAI part of civil AW169 production, which should run for decades. Opportunities for civil development work by KAI look very limited, though some of the LCH budget could be used to bring an early update of the AW169 onto the market in 2020.

Bell's offer would give KAI an almost all-new helicopter and great opportunity for engineering development but

also the most risk. It would surely cost the most, too. Bell and AgustaWestland were unable to respond immediately to a request for information about their proposals.

Whichever partner is chosen, KAI will have a substantial share in a military helicopter that, at least initially, will enjoy its own market. The LAH will be the only armed helicopter in this weight class with a cabin. If it is based on the AW169 or is newly designed with Bell, it will also be a thoroughly modern army helicopter.

Most members of KAI's Surion development team will work on the LCH-LAH, says the South Korean company. Despite the Surion experience, KAI adds that it still needs a partner's help with civil certification and the technology of main gearboxes and automatic flight control. Every advanced helicopter maker regards the latter two areas of know-how as its family jewels.

The LAH program has slipped and shrunk over the years. In 2009, the army had wanted to begin receiving 274 units of what was then the Korean Attack Helicopter by 2018. By 2010 the figure had slipped to 260, and last year industry officials said "more than 200." HI Investment & Securities now says the army needs 150 and the navy 50. ☛

Although the LAH-LCH will be based on a foreign design, KAI has built this mock-up of its concept.



SPACE

Launch Delay

Europe's future ISS role complicated by next-gen launcher debate

Amy Svitak Kourou, French Guiana, and Paris

The European Space Agency launched its fifth and final Automated Transfer Vehicle (ATV) to the International Space Station in July, with plans to retire the sophisticated cargo tug upon its fiery return to Earth in February. But as the 20-nation ESA closes a chapter in ISS history, its future support for the \$100-billion orbiting outpost remains in doubt.

As the lead nation in the five-partner program, the U.S. hopes to continue ISS operations four years beyond planned retirement in 2020. But other members—notably Russia and Europe—are less sure. ESA, in fact, is still debating how to pay for continued ISS participation through the end of the decade, let alone 2024, with a decision not expected until a December meeting of the agency's ruling council in Luxembourg.

Retirement of the ATV will leave Moscow in control of key aspects of the orbiting outpost in a period of rising political tensions with the U.S. and Europe. Russia's Progress transport vehicles will become the sole means of propulsive support to the ISS, including the ability to refuel the Russian Zvezda module, de-boost the space station's degrading altitude and occasionally maneuver it away from space debris.

Two issues central to the ISS debate will be a €205 million (\$275 million) tranche of funding needed to complete an ATV-derived service module designed to fly on NASA's Orion crew exploration vehicle in late 2017 (see [page 26](#)). Known as the Orion-ESM, the service module is part of a barter agreement between NASA and ESA that covers Europe's share of common operating costs aboard the ISS through 2020.

In addition, ESA member states will be asked in December to fund several hundred million euros in operating expenses necessary to keep Europe's Columbus module up and running through decade's end. Tentatively approved in 2012 during the agency's most recent round of budget negotiations, this money is now in contention as the ESA's top financial backers—France and Germany—debate whether to complete an upgrade of the Ariane 5 rocket, known as Ariane 5 ME, or start work on a more commercially viable successor, Ariane 6, or both.

Further complicating the ISS debate is Italy, which in 2012 cut its share of ESA's funding for the ISS from 19% to just 5%, leaving Germany—the station's largest contributor—to pick up the slack. Berlin has other battles to fight this year, however, including the need to secure €1.2 billion for the Ariane 5 ME while ensuring a meaningful role in Ariane 6.

Johann-Dietrich Woerner, head of German Aerospace Center DLR, says Berlin will neither increase its ISS contribution in December nor beg Italy to do likewise. "ESA should not be an organization trying to convince member states to pay for things," he said. "They should do it because they see the value from their perspective."

New Italian space agency chief Roberto Battiston agrees, acknowledging his government faces multiple demands in the space sector, and that it is struggling to find the resources to pay for them. In addition to increasing ISS spending, Bat-

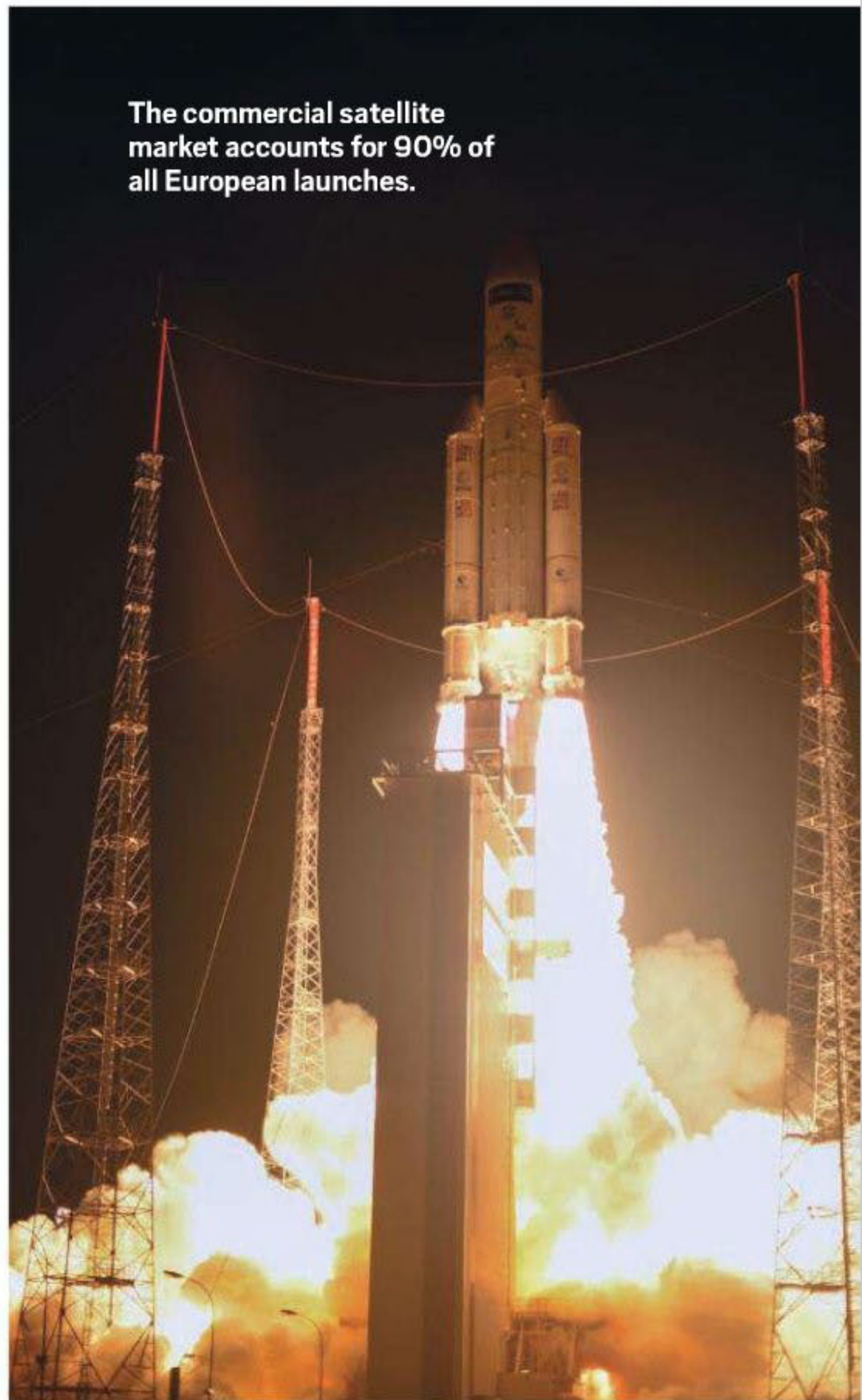
tiston says he must ensure the Italian-led Vega light launcher evolves to become a more powerful rocket while securing a role in Ariane 6 and winning continued support for the Italian-led ExoMars mission with Russia. But while fiscal challenges persist, Battiston says it is impossible to think Europe would abandon its human spaceflight ambitions.

"Can you see a world in 2020 with only China running a space station?" he asked July 28, on the eve of Europe's fifth and final ATV launch to the ISS. "Europe cannot escape the political argument."

The ongoing debate over when and why to build the next-generation Ariane 6 will no doubt take center stage in Luxembourg, with a decision on continued ISS support held hostage until discord over the launchers is resolved.

Unique among global space powers, Europe relies almost entirely on launches of commercial satellites to maintain independent access to space. In response to increased competition from new market entrants—notably the SpaceX Falcon 9—ESA and its industry partners are increasingly desper-

The commercial satellite market accounts for 90% of all European launches.



ESA

ate to sort out both the Ariane 6 design and the industrial organization that will develop, manufacture and launch it.

This was not the case two years ago. In November 2012, France alone saw the urgency of Ariane 6, and designed the rocket accordingly. The result was a smaller, less-capable, but also far less costly rocket that by 2021 could survive on a handful of government missions each year without relying as much on the commercial market.

Designed by ESA and French space agency CNES, the launcher comprised four identical solid-rocket boosters topped by a restartable liquid-fueled upper stage common to the Ariane 5 ME. Capable of lifting just 6,500 kg (14,330 lb.) to geosynchronous orbit for €70 million per mission, the design was aimed at streamlining Europe's sclerotic space industry, concentrating production across a handful of manufacturing and integration facilities, rather than the 25 sites that support Ariane 5 today.

However, the design was rejected by satellite operators as too small to lift large communications spacecraft, and its mostly solid-propulsion configuration left Germany cold.

As a result, Berlin pressed the merits of the status quo: Defer a decision on Ariane 6 and finish work on the Ariane 5 ME, a rocket 20% more capable than Ariane 5 that could enter service in 2018, keeping Europe's Arianespace launch consortium competitive while eliminating the need for some €100 million in annual ESA subsidies.

Since then, however, SpaceX has been making steady progress. The company has launched just three missions this year, after muscling through numerous technical and weather-related setbacks. But its slow yet dogged approach has lit a fire under skeptics in Europe.

"We now have to take into account the market of tomorrow," Woerner says. "It was a bit of a strange discussion during the last three years, because Ariane 6 was not based on goals but on one or two configurations; now we are in a totally different situation where we are not discussing the configuration, but the goals."

In June, Airbus and Safran—the two largest industry shareholders in Arianespace—proposed a joint venture that would merge their respective space divisions. The announcement coincided with a new Ariane 6 design backed by French President Francois Hollande and based on a dual-launcher concept with potential to balance Germany's expertise in liquid propulsion and Italy's heritage in solid-rocket engines.

The proposal includes a medium-lift rocket capable of sending 4-metric-ton payloads to low or medium Earth orbit for government customers, and a larger launcher with a 6-8-metric-ton lift capacity for commercial missions. Both rockets would be backed by an evolved Vega launcher that could send 1.7 metric tons to Sun-synchronous orbit, Battiston said.

The merger, expected later this year, is to form the core of a reorganized launch sector aimed at ensuring European autonomy in space while maintaining a competitive, long-term industrial base. But with the December ministerial looming, it also means scrapping 18 months of early design work by CNES and ESA, as well as efforts to implement more ambitious industrial base reforms.

"ESA and CNES have played significant roles in preparing the activities for the ministerial, in the context of which there will be further reflection, including the decisive step made by industry," said Genevieve Fioraso, the French secretary of state for higher education and research who will represent

France at the December meeting. "It is vital, if we are to find an agreed solution for Ariane 6 that will stick to the budgetary constraints we have and optimize the different launchers for different market segments."

In response, ESA and its principal launch vehicle backers are now multiplying meetings through the holiday month of August, preparing for a mid-September powwow among German, French and Italian ministers. The last-ditch effort will attempt to forge a compromise on the Ariane 6 design that falls within the financial constraints set by ESA governments, but which meets industrial and strategic objectives.

"ESA should not be an organization trying to convince member states to pay for things," DLR's Woerner argues.

Arianespace, which has remained largely silent on the launch vehicle debate until now, says it will contribute a market analysis of Ariane 6 options, with commercial fleet operators expected to review proposed designs in early September on the sidelines of an annual satellite conference in Paris.

In the meantime, as their governments prepare a long-term space strategy for the future, Airbus and Safran are rapidly setting up shop. In July the companies revealed their selection of a CEO—Alain Charmeau, who currently heads the space transportation division at Airbus Defense and Space—and unveiled plans for how the board of directors will operate. Eventually the merger is expected to absorb Arianespace, as well as other launch-hardware manufacturers, including MT Aerospace of Germany and Finmeccanica of Italy.

As part of the reorganization, Finmeccanica is likely to purchase Avio of Italy, which along with minority partner ASI, the Italian space agency, is a prime contractor for Vega.

But even with all stakeholders on board, differences remain as to how the rocket's development will unfold, and at what pace. For example, some ESA governments question whether to complete work on Ariane 5 ME while developing the larger Ariane 6 for commercial launches, or to abandon the midlife upgrade and start work on the medium- and heavy-lift Ariane 6 variants proposed under the Airbus-Safran merger.

Germany, on the other hand, wants to finish the midlife upgrade in parallel with development of the smaller institutional launcher. "Then in 10 years we could go to the heavy Ariane 6 variant," Woerner says.

France has made clear it wants to move full speed ahead with Ariane 6 development, and aims to settle the design in September ahead of the Luxembourg meeting.

"It's not going to be easy," said ESA Director General Jean-Jacques Dordain. "It is difficult to bring together reliability and competitiveness, to bring together all these different aspects, but we'll manage to do so."

Once a way forward on launchers is determined, ESA ministers will take a position on the space station.

"ISS is a crucial point if we continue with human space exploration with NASA," Woerner said. "Maybe the European service module could be a 50% barter agreement for transport capability of European astronauts beyond 2020. If we just stop now and send the drawings to the U.S., it would be a pity." ☛

Europe's final ATV is packed with 6,550 kg of supplies, including a record 2,620 kg of dry cargo.

Just the Beginning?

ATV retirement opens new chapter in U.S., European space cooperation

Amy Svitak Kourou, French Guiana

With launch of the fifth and final Automated Transfer Vehicle (ATV) last month, Europe's human spaceflight ambitions will shift to development of an ATV-derived service module that will give the European Space Agency (ESA) a critical role in NASA's manned space exploration program.

The last of the ATV cargo tugs launched July 29 atop an Ariane 5 ES rocket from the Guiana Space Center here, loaded with fuel, food, water and supplies bound for the International Space Station (ISS). The Ariane 5 rocket and ATV spacecraft—both built by Airbus Defense and Space—lifted off at 8:47 p.m. local time, with the cargo carrier inserted into a circular orbit at 260 km (160 mi.) altitude and 51.6 deg. inclination a little more than 1 hr. after launch.

ATV-5—named Georges LeMaitre after the Belgian priest, cosmologist and father of the Big Bang theory—is expected to rendezvous and dock with the ISS Aug. 12, where it will remain a pressurized part of the station for the next six months.

Known for its sophisticated guidance and navigation system, the ATV is the only space freighter fully capable of automatic rendezvous and docking with the ISS. Representing a combined investment of €3.75 billion (\$5 billion) to develop, produce, launch and operate, the ATV program is a collaboration of some 550 companies from a dozen ESA member states and has ferried more than 24,860 kg (54,810 lb.) of cargo to the ISS since its first resupply run in March 2008.

"Six years after its maiden flight, the ATV is still a unique vehicle demonstrating what ESA and European industry can do in serving European cooperation and innovation," says ESA Director-General Jean-Jacques Dordain, who touted the ATV-derived technology that is being incorporated into a service module that will fly on the Lockheed Martin Orion Multipurpose Crew Exploration Vehicle starting in 2017.

Known as Exploration Flight Test-1, the mission will see NASA's new Space Launch System send an unmanned Orion 70,000 km beyond the Moon before returning to Earth for an ocean landing. Within the combined \$22 billion exploration program, EFT-2 is scheduled to follow with a crewed test flight in 2021.

As part of a barter agreement between NASA and ESA, the Orion service module development covers Europe's share of common operating costs aboard the ISS through 2020.

Thomas Reiter, director of human spaceflight operations at ESA, says service module prime contractor Airbus Defense and Space is making progress on the project, having completed a system preliminary design review (PDR) in May. A critical milestone in the program's development, the PDR was delayed almost a year due to weight issues and other technical concerns that Reiter says have since been addressed. "The mass issues have been resolved, and our margin was increased a little due to the SLS upper-stage performance, so now we have a mass margin that is workable," he says.

The project schedule is tight, however. Reiter says ESA will sign a contract with Airbus Defense and Space for Phase C/D development this fall, ahead of a key budget meeting in December (see [page 24](#)), where member states will be asked to approve the final €205 million (\$275 million) of a total €455 million needed to complete work on the service module.

Adding to the pressure is a recent request by NASA to advance hardware delivery by three months, to December 2016 from March 2017.

"We have a lot of integration that has to be done in Cleveland with the service module on Orion," says William Gerstenmaier, NASA's head of human spaceflight and operations, to include vibration and acoustic testing at the NASA Glenn Research Center there.

Under the terms of the barter agreement, ESA will deliver one completed service module and a set of spare parts with engineering blueprints needed to assemble a second. Beyond that, says Gerstenmaier, ESA may choose to continue providing service modules or components under a follow-on barter arrangement—if member states opt to extend ISS participation beyond 2020. "It's a partnership, so if it's advantageous to both of us, if Europe wants to barter with us, then we'll figure out a way to do Service Module-2," Gerstenmaier says. "But we also entered into the agreement such that if this went south, we could manufacture it from the U.S." ☐

Ride-Sharing

Adoption of a catalog procurement mechanism clears a big government hosted-payload hurdle

Frank Moring, Jr. and Jen DiMascio **Washington**

U.S. Air Force adoption of a streamlined process to buy piggyback rides for government payloads on commercial spacecraft should go a long way toward accelerating the nascent hosted-payload industry, which has languished after a faltering start.

The USAF Space and Missile Systems Center (SMC) has awarded indefinite-delivery/indefinite-quantity (IDIQ) contracts worth as much as \$494.9 million each over five years to 14 companies it judges able to put military and civil payloads on commercial satellites. The goal of the Hosted Payload Solutions (HoPS) program is to save taxpayers' money by sharing the housekeeping services of power supply, data-handling and communications with the spacecraft owner.

"Let's say you wanted to put up a few

Following a series of launch delays, the Chirp hosted payload was decommissioned in 2013 after 27 months in orbit on an SES satcom.

transponders of your own for a particular waveform," says USAF Space Command chief Gen. William Shelton. "Why create a whole new satellite to do that, when there's available size, weight and power to do that?"

That has not always been the favored approach at the service, where ambitious officers sometimes saw more benefit in having development of a complete spacecraft on their resumes. Now tight budgets have put a premium on affordability, and under Lt. Gen. Ellen Pawlikowski's tenure as SMC commander, the service has pushed hosted payloads.

"When you look at the government cycle associated with getting funding allocated to fly particular missions, frankly, it's inconsistent with the commercial cycle," says Janet Nickloy, vice president of strategy for the Government Communications Systems Div. at Harris Corp. and chair of the Hosted Payload Alliance. "Getting hosted payloads as part of the strategy, and building in the budget and the contractual vehicle to do that are critical. HoPS allows us to check one of those boxes."

Companies winning the HoPS IDIQ contracts are: Astrium Government Services Inc., Harris Corp. Government Communications Systems, Space Systems/Loral, Millennium Engineering & Integration Co., Surrey Satellite Technology U.S., Orbital Sciences Corp., The Boeing Co., Exoterra Resources, Lockheed Martin Corp., Merging Excellence and Innovation Tech Inc., ViviSat, Intelsat General Corp., SES Government Solutions and Eutelsat America Corp.

Officers from the SMC Hosted Pay-

the NASA sensor package, which will be designed to scan North America in visible and ultraviolet wavelengths from its perch on a geostationary satcom for concentrations of ozone, nitrogen dioxide, sulfur dioxide and other pollutants.

After that, "I think the sky's the limit for us to pursue the hosted-payload business," says Shelton.

Nickloy estimates there are 30-40 hosting opportunities a year across the low-, medium- and geostationary-orbit (LEO, MEO and GEO) categories covered by the HoPS contracts. The second-generation Iridium-NEXT LEO satcom constellation includes hosted payloads in its business plan, and contract winner Surrey just announced it will make room on a second SSTL-150 bus to be launched in mid-2016 for hosted payloads that will ride with its own electronic testbed to evaluate components, processors and memory devices.



ORBITAL SCIENCES CORP.

load Office will brief company executives on upcoming hosting opportunities at a workshop this month, and try to match government requirements with hosting opportunities. Based on the lessons learned in getting USAF's Commercially Hosted Infrared Payload (Chirp) launched on an SES satcom, Nickloy says it is likely to take at least two more years before a government hosted payload is launched under the HoPS effort. The first probably will be NASA's Tropospheric Emissions: Monitoring of Pollution mission, which SMC has designated as the lead HoPS procurement (AW&ST May 20, p. 23).

Up to four of the HoPS companies will receive six-month study contracts worth as much as \$800,000 to find a ride for

One early military hosted payload under HoPS may be an experimental payload in GEO to evaluate V- and W-band frequencies, according to information circulated by SMC at an industry day in April. Other possibilities mentioned were a Compact Ocean Wind Vector Radiometer built by the NASA Jet Propulsion Laboratory for the Air Force Defense Weather Directorate; various Air Force Research Laboratory experimental payloads; a French-built Advanced Data Collection System designed to receive data from ocean buoys and electronic-tagged marine life for NASA and the National Oceanic and Atmospheric Administration; and, for the same civilian agencies, Search and Rescue Satellite-aided Tracking gear. ☛



Deep Waters

Britain could move soon to acquire ASW aircraft

Bill Sweetman Washington and Tony Osborne London

The U.K. is likely to move sooner rather than later to restore the long-range maritime patrol and antisubmarine warfare (ASW) capability that it lost in 2010 when the Nimrod MR2 and its intended replacement, the MRA4, were found to be unsafe to fly. Reports that the British government is considering a sole-source, non-competitive acquisition of the Boeing P-8A Poseidon are being taken seriously by potential bidders, including Airbus Military, Saab and L-3 Communications.

So far, there is no competition, because the U.K. Defense Ministry has not yet issued a formal requirement for a new maritime patrol aircraft (MPA). However, the government seems to recognize that the MPA gap must be closed as soon as possible, with a decision before or as part of next year's Strategic Defense and Security Review (SDSR).

In Washington on June 30, the Royal Navy's senior officer, First Sea Lord Adm. George Zambellas, noted that the British government "is reconsidering everything as the nation emerges from the recession," and that "maritime challenges in the Atlantic have reminded us how much value there is in MPA. I believe that [MPA] is an important investment and that it will happen."

One industry source suggests progress with the Royal Navy's new aircraft carriers is an important factor: "We believe that they will want an aircraft by the time the Queen Elizabeth is operational," the executive says. Without ASW aircraft, the carrier will require escort by Type 23 frigates on any deployment, and that fleet is already overworked.

Rising tensions with Russia underline the importance of a key ASW mission: protecting the U.K.'s ballistic missile submarines as they leave port. Since the retirement of the Nimrod, the Royal Navy has been forced to screen the movements of the Vanguard-class missile subs with its Merlin HM2 helicopters, but these are limited in range and numbers. The Royal Navy plans on a front-line fleet of 25 helicopters, out of 30 upgraded HM2s.

Discussions are taking place amid turmoil in British intelligence, surveillance and reconnaissance (ISR) programs. The Raytheon Sentinel R1, marked for retirement in the 2010 SDSR, has been reprieved after proving its worth in Libya in 2011. In June, Boeing executives in Seattle noted that the Royal Air Force's E-3D Airborne Warning & Control System

(Awacs) fleet has fallen behind the upgrade programs funded by all other Awacs operators and will become increasingly difficult and costly to sustain.

In February, then-defense secretary Philip Hammond confirmed that the MRA4 had been scrapped, not just because of cost increases and delays but because it was impossible to prove that the aircraft was safe to fly. The MRA4s were modified from 35-40-year-old MR2s, which were based in turn on the late-1940s Comet design, and the loss of a Nimrod MR2 XV230 in Afghanistan showed that RAF airworthiness standards were inadequate.

"It is a bit rich for him to say that the gap in maritime patrol cover was created by this government," Hammond said in a testy exchange with an opposition member of Parliament. The current team recognized that the previous government "had been investing in aircraft that . . . would never be certified and would never be able to deliver a capability," he said. Zambellas also confirmed last week that MRA4 was "headed for serious difficulties" connected with the design's age.

The Defense Ministry has worked to retain its maritime patrol skill set by sending a cadre of 32 RAF personnel to train in Australia, Canada, New Zealand and the U.S., which have established maritime patrol capabilities. The £3.2 million (\$5.4 million) initiative, named Seedcorn, is funded through 2019, but it could be halted in 2016 if the 2015 SDSR maintains a maritime patrol gap, documents state. Twenty of the 32 personnel have been exposed to the P-8 through operations at NAS Patuxent River, Maryland, or NAS Jacksonville, Florida, the P-8 schoolhouse. Four of the personnel at Patuxent River are being trained on the MQ-4 Triton and the others are flying on the P-3 Orion. A majority-British crew flying a P-8A with patrol squadron VP-30 won the U.S. Navy Fleet Challenge 2014 ASW competition in April.

The future of the U.K.'s airborne ISR, including MPA, is the focus of the Defense Ministry's Air Istar (Intelligence Surveillance Target Acquisition and Reconnaissance) Optimization Study (AIOS), being written by the U.K. Joint Forces Command. AIOS covers issues ranging from unmanned air systems to the replacement of Awacs. It is widely expected to report its findings to the Defense Ministry this summer, supporting the 2015 SDSR.

The urgency of the need, post-MRA4 risk-aversion and a

Airbus Military has delivered ASW-configured C295s to Chile and is in final discussions with a NATO customer.



history of cooperation with U.S. and Australian ASW communities point to the advantages of a P-8A buy, but even a fleet of nine P-8As (the number of MRA4s planned) would represent a \$2 billion-plus investment in aircraft alone, based on U.S. budget figures. Competitors are proposing aircraft one-third the P-8A's size, with much lower costs.

Airbus Military UK CEO Richard Thompson told Aviation Week at the Farnborough air show he is trying to "bust the myth" that the P-8 Poseidon is the only reasonable solution. Airbus is proposing a version of its C295 MPA, and Thompson says it will "meet 90% of the requirement," cost half as much to acquire and fly at 20-25% of the operating cost.

As well as producing surface-search MPA, Airbus has delivered full-up ASW systems on C295s for Chile and upgraded P-3AMs for Brazil. The C295's Elta Systems EL/M-2022 radar is superior to the P-8A's Raytheon APY-10, Thompson asserts, and Ultra Electronics' latest acoustic processing system, used on the upgraded Merlin HM2, supports multistatic active coherent (MAC) processing and "is ahead of the American solution." Airbus is offering doubled sonobuoy capability compared with the Chilean aircraft and has a wideband satcom product,



Saab is new to airborne ASW but has extensive experience in submarine combat systems.

which it may offer the U.K.; the P-8A has an Inmarsat terminal and will not get wideband until Increment 3, late in the decade.

The bigger P-8A has a longer range, "but 90% of the U.K. mission is within 500 nm," Thompson says, and the C295 would be fitted with a refueling probe for longer missions. It could therefore be refueled by the RAF's Voyager, unlike the P-8, which is equipped for boom refueling only. "You're not buying an aircraft with the P-8," Thompson notes. "You're buying a system of systems and a whole doctrine and concept of operations."

That Conops, he suggests, is moving away from the traditional approach to ASW. MAC in itself is a big change to acoustics—still the primary means of finding submarines—but the U.S. Navy, which starts its transition to MAC with the P-8A Increment 2, is also moving to high-altitude ASW, in which sonobuoy fields are laid and monitored, and torpedo attacks performed, from 15,000 ft. or higher. This involves a move to the wing-kit-equipped version of the Mk. 54 lightweight torpedo and new sonobuoys with an as-yet-undefined guidance system, because neither buoys nor torpedoes can be dropped accurately from high altitude without those features.

Saab plans to offer both maritime patrol and airborne early warning and control (AEW&C) systems to the RAF, based on the Saab 2000 platform. Operating at low altitude with more precise sonobuoy placement, too, the MPA may not need the triple-digit quantities of buoys carried by the

P-8A and planned for MRA4. Saab also is considering the use of the smaller G-size sonobuoys carried on the Merlin.

The Swordfish MPA could operate alongside the EriEye AEW&C aircraft, Saab proposes. EriEye has been upgraded in successive versions with better maritime surveillance capabilities and demonstrated its ability to track tough targets such as jet skis out to the radar horizon. Saab argues that the EriEye's lower operating costs would justify replacing the E-3D, possibly on a lease basis. "We have one customer with two EriEyes, and we provide all their maintenance and ground support," Erik Winberg, Saab electronic systems business development director, tells Aviation Week. "They fly one mission a day, and we have eight people in country."

Two recent improvements to EriEye are the Automatic Identification System (AIS) and Automatic Dependent Surveillance-Broadcast (ADS-B) receivers to locate and identify cooperative targets on the sea and in the air, respectively. ADS-B extends EriEye's air picture out to 720 km (450 mi.), almost twice the range of normal ADS-B. AIS can be fused with EriEye's active radar mode to identify individual ships out to the horizon.

Sensor-fused information can now be overlaid on sea charts and satellite images, and a terrain database can be used to calculate lines of sight. "We did not have the computing power to do that in real time until now," Winberg says, but the system has been equipped with a new commercial-off-the-shelf computer based in Core i7 technology and a 10-Gbps fiber-optic Ethernet system.

L-3, Selex ES and Ultra Electronics have teamed to offer Bombardier's Q400 turboprop airliner in ASW form. The three companies say the aircraft would be capable of delivering 80% of the capability of a P-8 but at less than half the purchase and direct operating costs. Panniers on the side of the fuselage under the wings will house auxiliary fuel tanks, extending the type's endurance to up to 10 hr., which could be boosted further through inflight refueling, if the customer demanded it. Under the fuselage is a canoe fairing with three compartments. The front one would contain a Selex-ES 7500E search radar for surface and overland search missions.

L-3 has purchased a Q400 that will be modified into an ASW demonstrator by Cascade Aviation Services of Mulkiteo, Washington. Systems will be integrated during 2015. The companies say the aircraft could be ready for service in four years, with integration work done in the U.K. Airbus and Saab are also citing the U.K. and European content in their proposed MPAs and the value of preserving U.K. ASW technology.

Thales is involved with Alenia Aermacchi's multimission ATR 72MPA which was developed for Turkey and uses Thales's Airborne Maritime Situation & Control System (Amascos) mission system, but it is not clear whether they will offer this to the U.K., although an Amascos-configured CN235 operated by the Turkish navy was displayed at the RAF Waddington air show last month.

Boeing argues that the P-8A is more affordable than its size suggests, because of the 737 platform's economics. Boeing could offer the option of leasing an initial batch of P-8s that would be fully paid for and added to the fleet later following the model of the RAF's C-17 fleet. Boeing executives also say that in some P-8A campaigns, the company is proposing a mixed fleet with a few Poseidons to chase submarines and a complementary force of its new Maritime Surveillance Aircraft, based on the Bombardier Challenger 605 business jet, to maintain a surface picture. ☛

Replacement Plans

Belgium considers F-35, other F-16 successors

Nicholas Fiorenza **Brussels** and Tony Osborne **London**

At long last, Belgium is formally beginning its search for a replacement for the air force's fleet of 54 F-16s. As Defense Minister Pieter De Crem, who appears to have favored upgrading its fleet with Lockheed Martin F-35s, prepares to leave office, the defense ministry has begun collecting information about replacement options.

On July 24, the defense ministry presented its "air combat capability program" to replace the F-16 fighters that will have been in the fleet for 40 years when they are expected to reach the end of their service life, from 2023-28. Belgium, which has under previous governments even considered an unmanned option, is looking for an F-16 replacement that is built to last.

"We do not need a combat aircraft, but rather a combat capability, which will last the next 50 years," said Lt. Col. Steven Lauwereys, who is responsible for the program.

Last month, the defense ministry sent a preparation survey for the program to NATO government procurement agencies for five possible successors. It went to the U.S. for the F-35 and F-18, the U.K. for the Typhoon, France for Rafale and Sweden for Gripen.

This is part of the program's preparation phase, during which the government will collect information until the first quarter of 2018. Next will come a one- or two-year programming phase in which this information is analyzed, followed by the acquisition phase in 2018 consisting of negotiations and a government-to-government agreement.

The budget and number of aircraft to be purchased will be determined after the preparation phase. But the defense ministry maintains its current ambition: two to four aircraft on quick-reaction alert 24 hr. a day, seven days a week in Belgium, plus a maximum of 10 aircraft on two foreign deployments. Belgian F-16s have participated in NATO air operations over the Balkans, policing Baltic airspace, and in Afghanistan and Libya. Six F-16s had been based in Kandahar as part of NATO's International Security Assistance Force, with regular deployments of four aircraft to Siauliai, Lithuania (as well as during Operation Unified Protector over Libya in 2011).

Belgium has still not formed a new government since elections on May 25. If the new government opts to continue the course reportedly advocated by De Crem to purchase Lockheed Martin F-35s, Belgium's fighter fleet would remain aligned with Norway and the Netherlands, which are re-

placing their F-16s with F-35s. Over the years, Belgium has improved interoperability through the European Participating Air Forces grouping of air forces equipped with the F-16; Denmark is another likely F-35 adopter. Cooperation has been closest with the Netherlands, with which Belgium plans to conduct joint policing of Benelux airspace with F-16s from 2016 until at least 2019, when the Royal Netherlands Air Force's F-35s are scheduled to begin entering service. Luxembourg airspace is already policed by the Belgian air force. Dutch Defense Minister Jeanine Hennis-Plasschaert has said joint air policing could be conducted regardless of the fighter types in service with the two countries' air forces, thanks to common NATO standards.

Choosing Typhoon or Rafale would separate Belgium from those old alliances but potentially bring it in line with larger European air forces. Belgium already has experience operating French combat aircraft with the Mirage 5 during the Cold War and shortly thereafter. And as for the Gripen, Saab has for years been arguing that Gripen is NATO-interoperable in terms of communication, armament, refueling and maintenance.

Boeing took the opportunity to market the Super Hornet to Belgium in July prior to the Royal International Air Tattoo and Farnborough air shows in the U.K. The two demonstration aircraft were based for a week at Florennes air base in Southern Belgium, home to two squadrons of F-16s, where Belgian pilots were invited to fly in the aircraft.

However Belgium's decision cycle could put the Super Hornet out of contention, since its production beyond 2016 is uncertain and is contingent on additional orders from the U.S. and elsewhere. The week before, the two aircraft had been at the Karup Airshow in Denmark, where Boeing is responding with the aircraft for Denmark's future fighter requirement, for which requests for proposals had to be delivered in late July.

Belgium's decision will be up to whichever coalition forms the next government. The latest coalition negotiating the formation of a government includes De Crem's party as well as a faction that opposes selection of the F-35. ☐

Belgium's F-16s are expected to reach retirement age between 2023 and 2028.



TONY OSBORNE/AW&ST



The high cost of the F-22 was driven by stealthy features, including a small weapons bay.

Eyes on the Horizon

Limited F-22, F-35 firepower magazine drives USAF investment plans

Amy Butler **Washington**

Eyeing emerging threats amid a constrained budget environment, and consumed by the Lockheed Martin F-35's high cost, the U.S. Air Force is already studying what the "sixth-generation" of air dominance capability for the service should be.

Air Combat Command Chief Gen. Mike Hostage says he is agnostic on whether the next generation of Air Force combat capability should be manned, unmanned or even a fighter. "It isn't necessarily another single-seat fighter," he said July 29 at a breakfast in Washington. "If it is the enter button on the keyboard that makes all the adversaries fall to the ground, I'm okay with that."

Because of the "tortuous" nature of the acquisition process, "we are already behind the line to get something on the ramp," he said. "I think it is existential that we build the future fleet." Hostage says he is willing to accept risk in the interim by shifting money from upgrades to existing fighters to provide seed money for the so-called sixth-generation system. This includes scrapping plans for the Combat Avionics Programmed Extension Suite and structural work for the F-16s expected to remain in the fleet despite downsizing.

This "sixth-generation" system is so dubbed as a follow-on to the "fifth-generation" of stealth, speed and avionics/sensor fusion offered by the F-22 and F-35. It will have to operate with the forthcoming Long-Range Strike Bomber; the Air Force recently issued a re-

quest for proposals for 80-100 stealthy aircraft, according to Air Force Chief of Staff Gen. Mark Welsh. This kicks off a long-awaited competition between a Boeing/Lockheed Martin team and Northrop Grumman, with a goal of a unit price at or under \$550 million.

Still, the all fifth-generation fleet once envisioned by the Air Force remains elusive. Flight restrictions on the F-35 are "near-term," and Hostage does not think the root cause of the excessive friction in the third stage integrally bladed rotor in the low-pressure turbine that led to a June 23 F-35A F135 engine fire will jeopardize achieving the Air Force's initial operational capability for the single-engine stealthy jet, planned by August 2016.

The fire prompted a fleet-wide grounding for three weeks, followed by a limited flight envelope for all three variants of the aircraft. For two weeks they have been flying only in a limited envelope, hampering progress in flight testing, including the weapons releases required for the U.S. Marine Corps to declare initial operational capability in one year with the F-35B. Operational aircraft are limited to 0.9 Mach and -1 to 3g under normal acceleration. Flight-test jets are approved for a slightly more rigorous 1.6 Mach and -1 to 3.2g under recently relaxed guidelines.

Hostage acknowledges that the "magazine" for today's fifth-generation fighters—the F-22 and, eventually, the F-35—is shallow. Each can carry only a maximum of eight ground-attack

Small-Diameter Bombs. Physics limits its magazine options for these aircraft, as the stealthy design requires small internal weapons bays.

Hostage hinted, however, that the Pentagon is funding classified efforts to maximize firepower. At one point, the service pursued the so-called Joint Dual-Role Air Dominance Missile (JDRADM), meant to combine the air-to-air capabilities of the Amraam with the radar-killing air-to-ground attack capabilities of the HARM missile into one airframe. That project—later dubbed the Next-Generation Missile—fizzled; some sources suggest research may be continuing under a classified program.

And it is likely the service will pursue directed-energy options for the sixth-generation system. "Amazing developments in the [directed energy] arena" have been made and this technology "holds great promise," Hostage said. He did not provide details on programmatic and added that it was not clear yet whether directed-energy capabilities would be mature enough to deploy on the sixth-generation system.

Directed energy is one of five areas highlighted by the Air Force as investment items for the future fleet; also included were unmanned aerial vehicles, nanotechnology, hypersonics and automation. These are included in a new paper, "America's Air Force: A Call to the Future," which outlines a strategic framework against which the service plans to budget for decades to come. ☐

Safety Schism

Oversight agencies face myriad obstacles to ensuring universal air security

Karen Walker **Montreal**

The commercial air transportation industry is moving to address systemic safety gaps exposed by the shooting down of Malaysia Airlines Flight 17 (MH17) in July. The problem the industry has, however, is that solutions to this crisis lie beyond the purview of the commercial side, whose representative organizations have little to no power to enforce change.

MH17 is believed to have been destroyed by a surface-to-air missile (SAM) while at 33,000 ft. over Ukraine. The Boeing 777-200ER was on a scheduled Amsterdam-Kuala Lumpur run July 17. All 298 people onboard were killed. The U.S. says the SAM was of Russian origin—fired by Russian separatists in the Ukraine area where fighting has been ongoing since spring. The aircraft had been authorized to fly that route, initially by European air traffic controllers and then by Ukraine ATC.

The chiefs of the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), Airports Council International (ACI) and the Civil Air Navigation Services Organization (Canso) held an emergency meeting in Montreal July 29 to discuss the ramifications of MH17 and how intelligence about potential military threats to airliners can be better collected and disseminated. They and other major global aviation organizations are forming a high-level international task force of state and industry experts to look at airspace security. The findings will be submitted to a special meeting of the ICAO Council within weeks and a high-level safety conference of all 191 ICAO member states will be held in February.

"While aviation is the safest form of transport, the MH17 incident has raised troubling concerns with respect to civilian aircraft operating to, from

and over conflict zones," ICAO, IATA, ACI and Canso said in a joint statement. It emphasizes a resolve to work together toward a solution, noting: "As a first step, states have been reminded by ICAO of their responsibilities to address any potential risks to civil aviation in their airspace."

Article 9 of the Convention on In-



Airline experts check debris at the crash site of flight MH17, which went down last month over eastern Ukraine.

ternational Civil Aviation, commonly known as the Chicago Convention, says that individual states are responsible for the safety and security of civil aircraft operating through their airspace and where there is armed conflict. Doc. 7300 of the article specifies that "each contracting state may, for reasons of military necessity or public safety, restrict or prohibit uniformly the aircraft of other states from flying over its territory. . . . Notices to airmen or other communications containing the necessary information, advice and measures to be taken should then be issued."

IATA CEO/Director General Tony Tyler said at a briefing after the Mon-

treau meeting that MH17 had "exposed a gap" in the air transportation system. "Airlines need clear guidelines and information on where to operate safely," Tyler said. "This is the responsibility of states and there can be no excuses. We need essential and actionable information. Industry is ready to assist in any way possible to make this happen."

ACI Director General Angela Gittens says the task force would work to "connect the dots" with military and intelligence organizations. "We need to engage outside of [commercial] aviation because the solution lies outside."

The air transport industry therefore wants, via ICAO, to find fail-safe channels for conveying essential threat information to civil aviation authorities and industry. But given the potential sensitivity of that information, this will be difficult. Many of the world's state-owned military and intelligence forces will be unwilling to share information.

"Intelligence-sharing is part of the challenges that the industry now faces," ICAO Council President Olumuyiwa Benard Aliu says. "We have to talk to the military authorities and we anticipate they will be invited to take part in the task force," he notes.

Even more problematic is how to ensure safe passage for airliners through airspace over conflict zones where weaponry such as SAMs are in the control of non-state rebels. These so-called small wars have now become a potential, albeit statistically tiny, threat to commercial air transport. But players in these wars typically are not signatories to either the Chicago or the Geneva Convention.

And if ensuring state compliance with Chicago proves difficult, it will be even harder to implement and enforce a second call by the air transport organizations. They are seeking, through a United Nations framework, measures that would "govern the design, manufacture and deployment of modern anti-aircraft weaponry." Effectively, that is a call by commercial aviation for global arms control. While that is an understandable desire, it likely will not be an achievable solution to what is a political problem. ☐

True Colors

Move into flight-simulation market rewarded with manufacturer deals for new Textron unit

Graham Warwick **Washington**

Few sectors of the aerospace industry are as competitive as flight simulation. Commoditization of the core technologies has lowered the barrier to entry, but the sustained investment required to stay ahead and the customer attention needed to retain business has led to a high mortality rate among new entrants. Those companies that have carved out niches have found it hard to break into the larger market.

Individually, Montreal-based Mechtronix and Florida-based Opinicus were small privately held companies that, in the course of more than 25 years, had made useful inroads into the market to

Boeing's 737 MAX full-flight simulator will be based on the FFS X product.

supply and upgrade commercial and military flight simulators. But they had not managed to make a significant impact on the respective market shares held by long-time industry leaders CAE and L-3 Link Simulation & Training.

In November 2013, both Mechtronix and Opinicus were acquired by Textron, which already had a presence in the maintenance-trainer market through subsidiary AAI. In April, the merged companies were branded TRU Simulation + Training, Mechtronix becoming TRU North and Tampa-based Opinicus TRU South. In July, TRU showed its new mettle, scoring key flight-simulator contracts from Boeing and Bell Helicopter.

In its first major award under its new identity, TRU has beaten the bigger players to win the prestigious contract to supply Boeing with the first flight-training equipment for the 737 MAX. The initial suite of devices will be delivered to Boeing Flight Services in 2017, and will comprise a Level D full-flight simulator, high-fidelity flat-panel training device and 10 classroom desktop virtual trainers.

Boeing has options to acquire 15 suites, says TRU President and CEO Jim Takats. The simulator maker is also

in discussion with initial MAX customers requiring flight-training equipment, says George Karam, vice president for air transport simulation. The 737 MAX devices will be produced in Montreal and will be based on the former Mechtronix FFS X simulator and FFT X trainer products, with enhancements drawn from Opinicus and others now in development within TRU, Karam says.



TRU SIMULATION + TRAINING

Developing the first-of-type flight simulator for a major manufacturer is a sought-after position, and the Thales simulation business—acquired by L-3 Link in 2012—was tapped by Boeing to supply training equipment for the 787; CAE developed the first 777 and 747-8 flight simulators. Karam believes Boeing selected TRU because of its technology and customer responsiveness, noting that his company has just completed qualification of a 737NG simulator at Boeing's training center in Singapore.

TRU also will build the first full-flight simulator for Bell's Model 525 medium twin-turbine helicopter, which will fly this year. The Level D simulator is to be operational in the first quarter of 2016, in Bell's Fort Worth training center, and will be built at TRU South,

drawing on the former Opinicus's experience with military helicopter simulators, including for the Sikorsky HH-60G Pave Hawk, HH-60J Jayhawk and CH-53E as well as the Bell AH-1W, Karam says. Bell is a sister company of Textron.

Bidding to supply the first 525 simulator began before the acquisition by Textron, so the contract was won competitively, says Takats. The deal launches TRU's Odyssey H helicopter simulator model, which has electric motion, vibration platform and a wide, 240-deg.-horizontal by 80-deg.-vertical visual system. The system will use an image generator supplied by RSI and ultra-high-definition, 4-megapixel projectors; TRU will develop offshore

and other visual databases.

Although TRU will sell simulators directly to aircraft buyers, in the air-transport market the company will not compete with the original equipment manufacturers to provide training services, Takats says. TRU will be a training provider for the business and general aviation markets, he notes. In the case of the 525, the company will provide instructors, but they will be trained by Bell. The

simulator company also has acquired Carlsbad, California-based ProFlight, an FAA-approved Part 142 training provider specializing in the Cessna CJ-series light jets and Conquest turboprop twin.

TRU continues to grow its market, meanwhile, selling a Level D simulator for the Bombardier CRJ700 to China Express Airlines and a Level D Airbus A320 to Ansett Aviation Training in Australia. Regional-aircraft manufacturer ATR has placed an FFS X Level D full-flight simulator for the ATR 72-600 at Avianca's training center in Bogota, Colombia. "We will sell a couple of other Level Ds this year in the air transport market and there are some [deals in process with] business aviation OEMs that we hope to finalize," says Takats. ☛

Alive and Kicking

EAA AirVenture highlights product improvements, enduring passion

John Morris, Kerry Lynch, Fred George and John Croft Oshkosh, Wisconsin

Airframers, suppliers and aviation enthusiast alike make the journey here for the Experimental Aircraft Association's (EAA) AirVenture every year not so much to make sales, but to renew their commitment to and passion for grassroots aviation past, present and future. Despite the relaxed atmosphere—a spokesman for a major Brazilian company says this is the only show where he “actually has time to talk to people”—much business does transpire and significant milestones are achieved.

Boeing and Airbus both made news, with Boeing launching a program to address anticipated shortages of airline pilots, and

maximum range increase of 58% over the aviation gasoline-fueled Skyhawk (to 1,012 nm) and a boost in maximum cruise speed to 131 kt. with the Continental CD-155 diesel engine. Fuel burn will drop by 25% with the diesel option, which costs \$65,000 more than the \$435,000 price tag for the avgas-powered version. Cessna expects to certify the new model next year. While the company had originally hoped to certify the diesel Skylane last year, the program was set back in part due to an emergency landing of the test aircraft a year ago after an issue with the Safran SMA engine.

Meanwhile, Flight Design says its new C4 four-seat light aircraft will not be held up by the FAA's two-year delay on rewriting the Part 23 regulations that cover standards for general aviation aircraft. Instead, the C4, which is being used as “the guinea pig” to help guide the rewrite of those rules in both Europe and the U.S., will be certified next summer under the current European Aviation Safety Agency (EASA) CS Part 23 rules, which the company says are “softer” and not absolute. The certification will carry a “special condition” that will say the C4 must meet the new rules when they are written, and with EASA certification, a “validation” process will qualify the C4 for FAA certification.

Among the C4's radical features are a crashworthy “safety box” encompassing the cabin, developed as a project of the German government. Rather than design just the seats to absorb impact, the cabin, firewall, landing gear, restraints and interior have all been engineered into a protective safety system that directs load paths away from the occupants. The rewritten Part 23 rules, which the FAA and EASA hope will be common to both certification authorities, will recognize such advances in technology.

Nextant Aerospace, which is undertaking its second remanufactured aircraft, the G90XT, unveiled a new Garmin G1000-based cockpit. The flight deck, on display here in a cockpit demonstrator, features two large primary flight displays and a multifunction display cockpit with single-lever power control for each engine, integrated electronic engine management, digital pressurization and an all-new environmental cooling system. Nextant hopes to certify the \$2.4 million General Electric H75-powered turboprop by year-end, selling the aircraft for

Cessna will soon certify the diesel Cessna 182 Skylane (foreground) and unveiled the diesel Cessna 172 Skyhawk.

Airbus committing resources for a project to fly a glider above 90,000 ft. in less than two years. Beyond the heavyweights, action at the general aviation show ranged from new product introductions and upgrades to advances in engine technologies and avionics.

Cessna introduced the diesel 172 Skyhawk JT-A at the show, a companion to the diesel 182 Skylane the company hopes to certify this month. The Skyhawk JT-A will have a



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and follow the news from
EAA AirVenture at
AviationWeek.com/Oshkosh



Airplane campers fill the North 40 parking area at Oshkosh.

ALL PHOTOS MAUREEN SPUHLER/AW&ST

AviationWeek.com/awst



With the slogan "Beware of (having a) Blast," the Sonex SubSonex Personal Jet is about to enter production as a quick-build kit.

\$1.4 million less than the current King Air owner, Textron. The company also refurbishes Beech 400s as the Nextant 400XTi.

Cirrus, which publicly debuted its conforming Vision SF50 single jet on July 27, is planning to add the next two models into the flight-test program by early next year as it continues to progress toward a late 2015 certification for its first jet product. C-Zero flew for the first time in March and has since been used for basic flight characteristics tests. The aircraft flew over a crowd of several hundred attendees at the Cirrus exhibit on the eve of AirVenture, then rejoined the test program in Minnesota. Once the next two aircraft join the program, C-Zero will be modified for an inflight parachute deployment.

Also at the show, Mooney International handed over the keys of its first newly built aircraft on July 29, marking the return of the high-performance piston-powered Mooney aircraft lines to the market after a five-year hiatus, thanks to a cash infusion from China.

Many other unannounced aircraft models are waiting in the wings. Lycoming Engines says it is working on as many as 25 "active" OEM engine integration projects for general aviation, most of which are outside the U.S. Mike Kraft, senior vice president and general manager for the Pennsylvania-based company, says the number of engines is not so much an indicator in an upswing in the market, but more a trend in niche aircraft. "If you're paying a couple hundred thousand dollars for an aircraft, it must fit your mission," he says of the new aircraft programs. "I can't say that the number of aircraft produced is increasing, but I can say that the introduction of new products remains healthy." One of those new products is Italian airframer Tecnam's P2010, for which Lycoming is supplying a 180-hp engine. Tecnam revealed here that it had gained EASA approval for the four-seat, low-wing single. Lycoming also will send the first engines to Tecnam later this year for the its new P2012 twin development program, which uses 350-hp TEO-540 engines with electronic controls.

The combination of electronic controls, sensors from the

automobile industry and unleaded fuels coming to the U.S. market will be the spark for innovation in new engines and engine controls, says Kraft. Included are single-lever power controls and new engine monitoring displays that will simplify what pilots need to know. Kraft says there could be indicator lights for "no takeoff" or "limited time of operation" before required landing. New unleaded fuels being tested are also providing the opportunity to reevaluate the internal workings of engines as the FAA moves forward with a planned transition to unleaded aviation fuel by 2018, which will include an ASTM specification, type certification and availability of the fuel.

Lycoming's main competitor, Continental Motors, unveiled its next diesel engine at the show, a 300-hp-range engine to be certified in 2016.

Very little noise was made by electric engines at AirVenture, however, with only three or four electric aircraft in at-



Electric flight pioneer Mark Beierle plugs in at one of EAA AirVenture's charging posts.



A rare sight: Private owners fly their ex-military T-33 jets in formation.



tendance, a noteworthy change from the strong emphasis on the new technologies over the past few years. The action contrasts with news made by the Airbus Group earlier this summer that it would enter the general aviation market with two all-electric models, the two-seat and four-seat e-Fan.

On the avionics front, there was a flurry of new product announcements aimed at the owners of approximately 150,000 general aviation aircraft that will be required to install Automatic Dependent Surveillance-Broadcast (ADS-B) avionics in their aircraft by 2020. The increase in competition from

new vendor entrants and products—most notably L-3 Communications with its new Lynx line of ADS-B units—is expected to drive down costs for owners who are beginning to accept the FAA's assurance that the deadline will not be extended and are starting to inquire about retrofits. "What's holding the process up is aircraft owners understanding what is needed," says John Uczekaj, president and CEO of Aspen Avionics. "We do see people starting to buy, and that will accelerate over the next 12 months as they really understand what they want and pull the trigger." ☺

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Never Again

After MH370, industry makes hard commitment to 'soft' tracking mandate

Royal Australian Air Force AP-3C pilot Nicholas Chapman searches for traces of Malaysia Airlines Flight 370 over the Southern Indian Ocean.

John Croft **Washington**

The notion that a \$250 million, state-of-the-art Boeing 777-200ER could vanish without a trace seemed ludicrous until March 8, when Malaysia Airlines Flight 370 (MH370) dropped from Malaysian radar screens in the middle of the night over the Gulf of Thailand.

At first incomprehensible, the reality of loss hit home when after 30, 60, 100 days, no trace of the aircraft had been found despite a massive search, estimated to be the most expensive to

date. A new \$60 million underwater mapping survey over the next year on a curved swath of nearly 20,000 sq. nm in the southern Indian Ocean may yield similarly hollow results.

Within the airline industry, the vacuum of information about the causes of the disappearance has spawned fears of waning public confidence that evoked memories of the two-year search for Air France 447's (AF447) resting place and launched a call for immediate voluntary improvements in how airlines keep track of their aircraft. Longer term, the industry is counting on the International Civil Aviation Organization (ICAO) to mandate upgrades

Road Map to Global Flight-Tracking Standards

2014

March 8

- MH370 disappears from radar over the Gulf of Thailand en route from Kuala Lumpur to Beijing.

March 31-April 2

- International Air Transport Association (IATA) convenes Operations Conference in Kuala Lumpur and creates Aircraft Tracking Task Force (ATTF) to focus on identifying near-term options for global tracking of aircraft, including a concept of operations (Conops).

May 12-13

- International Civil Aviation Organization (ICAO) holds Special Meeting for Global Flight Tracking in Montreal and reaches consensus to track all airline aircraft.
- IATA agrees to early voluntary implementation; ICAO to develop standards in parallel, while developing global standard on a parallel track.

May 26-27

- International Telecommunications Union (ITU) holds Expert Dialogue on real-time monitoring of flight data in Kuala Lumpur.
- ITU asked to provide necessary spectrum allocations for emerging flight-data monitoring needs and work with ICAO to implement it.



Listen *Avionics & Safety Editor John Croft, Executive Editor Jim Mathews and ATW's Aaron Karp discuss what is needed to overcome the challenges of global flight-tracking in our latest Check 6 podcast:*
AviationWeek.com/podcast

ROYAL AUSTRALIAN AIR FORCE

that may include real-time streaming data from the aircraft's "black boxes" when an anomaly takes place. French authorities in the 2012 final report on AF447 recommended streaming data and deployable emergency locator transmitters as potential solutions to long, expensive searches.

"As far as the industry goes, one event is too many," says Kevin Hiatt, senior vice president for safety and flight operations at the International

Air Transportation Association (IATA). "We've drawn the line in the sand and said we're going to come up with some options right now for the near term to provide additional ways to appease the flying public that it is safe to be there."

IATA's resolve manifested itself in the creation of the Aircraft Tracking Task Force (ATTF) on April 1 as the airline industry came together for an annual event that had been scheduled to take place in Thailand, but was later moved to Kuala Lumpur due to political strife. "A lot of press put together two things that don't belong together: that if we had had streaming data we would not have had the accident," says Nancy Graham, director of ICAO's Air Navigation Bureau, who attended the meeting. "That's not true. But unfortunately in a region hungry for information, that was a very hard thing to unwind."

The need for streaming data—basic flight parameters, downlinked at a high rate via satellite links during an emergency—was a key lesson learned in the 23-month search for AF447's flight data and cockpit voice recorders, where the search zone was a 40-nm radius around the final transmitted position. For MH370, the search zone is now 17,500 sq. nm. ICAO's rule changes after the AF447 accident include longer battery life for the existing underwater locator beacons on the "black boxes" and new low-frequency locators on the devices—but not streaming data or deployable flight data recorders.

ICAO is taking renewed interest in streaming data, but it is taking baby steps, developing rules that will dictate how all airlines must track their aircraft, including an "early notice" of and response to abnormal flight behavior. Graham is spearheading the effort, which could take two years or more.

Until then, IATA has agreed that its members will voluntarily start tracking with existing onboard equipment and a new batch of procedures being developed by the ATTF. The details of exactly who needs to begin tracking and how they should do it are being closely held by IATA, with initial results to be presented to ICAO in September. ATTF members include ICAO, the Flight Safety Foundation, Boeing, Airbus, Bombardier and Embraer.

Hiatt, who is chairman of the five-member steering group overseeing the ATTF, says there are three "work streams" underway. One group is developing a concept of operations (Conops) for global flight-tracking; another is examining the current state of flight-tracking to determine "where the gaps are;" and a third is coming up with the minimum requirements that any tracking system should meet. "Out of those three work streams, we'll be able to produce a report that will address most of everything that everybody has ideas about," Hiatt says.

He stresses that IATA's actions on enhanced global aircraft-tracking are meant to go into effect quickly once the ATTF's work is confirmed at IATA's board of governors meeting in December and subsequently presented to its airline members. IATA's 240 member airlines account for 84% of global air traffic. ICAO will hold a "high-level safety conference" in February, where Graham anticipates the ATTF's conops will be approved as part of a broader effort to draft performance-based international standards that she estimates can be done in two years, a rapid pace for a new ICAO rule.

Beyond that, ICAO is investigating midterm initiatives that include space-based surveillance (see [page 42](#)), improving search-and-rescue notifications (see [page 44](#)), accurately defining an accident location (see [page 46](#)), and gaining additional spectrum for "safety of life" aviation services. Long-term upgrades ICAO is considering include cloud-based remote storage of flight information (see [page 47](#)).

Industry appears to be split as to what IATA will recommend in September. "There are two opinions that are out there," says Matt Bradley, president of streaming data provider, Flyht Aerospace Solutions. "Some say [the ATTF will present] watered-down recommendations that basically say you've got to be able to track your aircraft or be able

June 11-13

- IATA ATTF holds first formal meeting and launches effort to define current state of flight tracking with member and non-member airlines, air navigation service providers.

September

- IATA ATTF to present preliminary Conops for global flight tracking to ICAO in Montreal.

December

- IATA communicates ATTF findings to member airlines.

2015 February

- ICAO to hold high-level safety meeting in Montreal to approve Conops from ATTF and move forward in developing a global tracking standard.

2016

- ICAO to publish global flight-tracking standards.

to contact your aircraft within a certain amount of time, and the industry will be given years to implement that. Others say this is a wake-up call for the industry and we're going to see some very strong recommendations that say you have to positively verify when your aircraft is not reporting when it should otherwise be reporting."

A key part of ATTF's work to date has been to find out the state of affairs in airline tracking, which is required by ICAO but not well-defined. "All airlines should know where their aircraft are, but all airlines don't," says Graham. "There are reasons for that. Some are technology, some are procedural."

Unlike surveillance, which means knowing an aircraft's position accurately enough to provide air traffic control (ATC) separation services, tracking refers to knowing the relative location

or state of an airline's assets, and practices vary significantly across company and geography. In oceanic regions, it is often the case that neither the airline nor ATC has adequate situational awareness. Although 80% of widebody aircraft flying long-haul oceanic routes are equipped with the Future Air Navigation Systems (FANS) to supply ATC with automatic dependent surveillance-contract (ADS-C) position reports over satellite networks using the Aircraft Communications Addressing and Reporting System (Acars) (see graphic), a number of airlines have not activated the service (nor are they required to).

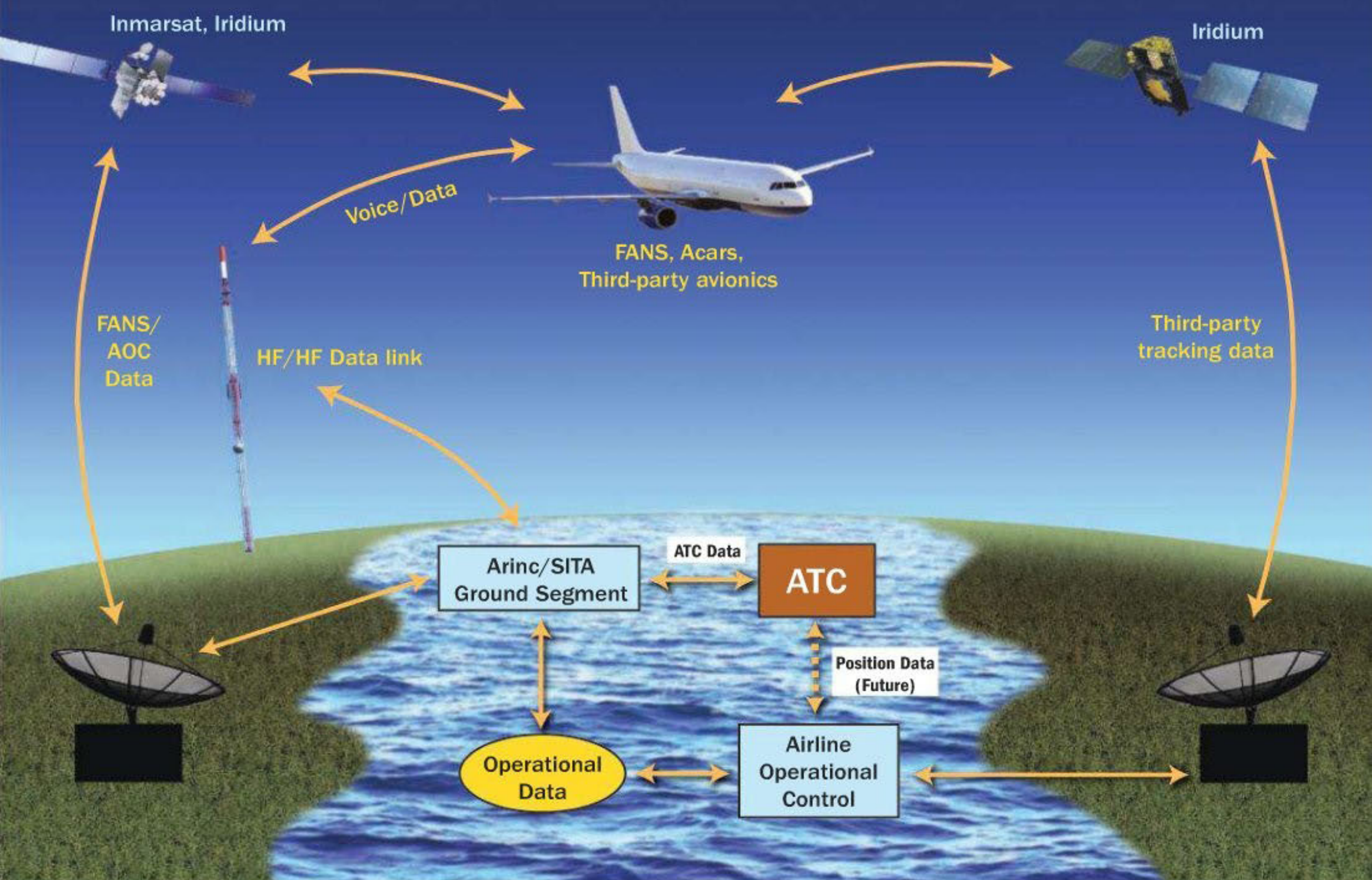
In some cases, routes do not yet have ATC systems that can accept the data. Both MH370 and AF447 were ADS-C-equipped. However, in MH370's case, the aircraft was under radar control when it dropped from radar screens,

negating the need for remote position reporting. When controllers do receive ADS-C reports, the same information is not routed to airline dispatchers, for whom remote communications are usually tied to airline operational control (AOC) data—engine reports, weather information and arrival gates—that are passed back and forth over Acars.

A small number of airlines are buying independent third-party systems, like Flyht's automatic flight information reporting system, for sending position reports, anomaly alerts and other operational data directly to the AOC through the Iridium satellite network.

For airlines using ADS-C, the system generally transmits its position to controllers over the Inmarsat or Iridium networks through SITA and Arinc distribution channels every 10 min., which translates to a granularity of about

Typical Tracking Options for Oceanic and Remote Areas



Operational Data = Takeoff and landing times, weather, gates, engine reports.

ATC Data = Navigation information, aircraft position reporting, oceanic clearances, weather, etc.

80 nm between known locations at airline-type cruise speeds. Search-and-rescue teams want a final position of 4 nm or less, which translates to a position report around every 30 sec. or less. ADS-C can be set up to do this, automatically increasing its reporting rate to as often as once per second when predefined anomaly conditions occur. Satellite data provider Inmarsat says it offers “free” ADS-C reports every 15 min., and faster reporting (every 5-10 min.) for about \$10 per flight, “far below potential fuel savings” gained by the closer separation standards that ATC can provide with the enhanced surveillance.

The perfectly legal alternative to ADS-C for surveillance is legacy voice communications at select way points using high-frequency (HF) radios that bounce signals off the atmosphere to land-based antennas, a system that is often noisy and leads to missed reports. Before working at Flyht, Bradley used to fly Airbus A330s from New York to Ghana, making voice position reports over HF radio every 60-90 min.

“If you didn’t make that position report, because you had a bad HF link or for some reason you couldn’t make contact, you could be [out of communication] 2-3 hr.,” he says. “It’s not so rare that you wouldn’t have those position reports.” He advocates for “positive tracking” by airlines, a feature Flyht is providing to 30 airline customers. “When something that is supposed to happen doesn’t happen, or when something that isn’t supposed to happen, happens, it puts the information right in front of the dispatcher.”

The ATTF’s Conops and minimum system performance requirements will by all accounts address those types of questions with a palette of options that carriers can voluntarily implement based on their equipment, operations and the regions in which they fly. It is not clear if any options being proposed would have helped in the case of MH370, as onboard communications systems were either shut down or failed. “We do know there are differences right now in the world with carriers who are tracking their own aircraft as far as how often,” says Hiatt. “We’re focusing more on the broad base to make sure that aircraft are being tracked, and then we’ll get into the granularity of options of how often or when they need to be tracked, whether only during a non-normal event or throughout the entire regime of the flight.”

A BRIEF HISTORY OF FLIGHT-TRACKING

John Croft [Washington](#)

If not for a Federal Communications Commission denial in 1987, airline tracking today could have been much more holistic than the piecemeal system the global industry is attempting to modernize in the wake of the March disappearance of Malaysia Airlines Flight 370 (MH370). Arinc, at the time owned by a group of airlines, had petitioned the FCC in April of that year for a license to use a portion of the L-band, which was then dedicated to the Aeronautical Mobile Satellite Service-Route (AMSS-R), to enable airlines to communicate information about safety and schedules on international routes. The company had secured airline backing to build and launch its own geosynchronous satellite communications network consisting of three satellites to cover the globe.

Satellites were seen as the way of the future. Arinc had introduced the aircraft communications addressing and reporting system (Acars) data link nine years earlier, in 1978, to allow aircraft to communicate with data rather than voice alone. Over land, the system used a terrestrial network of radio towers owned by Arinc, but there was no in-house solution for position-reporting to air traffic control and aircraft operational control (AOC) to airlines for weather, gate and other information for over-water flights, other than to use the existing high-frequency (HF) voice networks. An alternative choice would have been to pay for third-party data communications services through Inmarsat’s evolving marine communications satellite network, which was gearing up to begin providing voice and data services to aircraft.

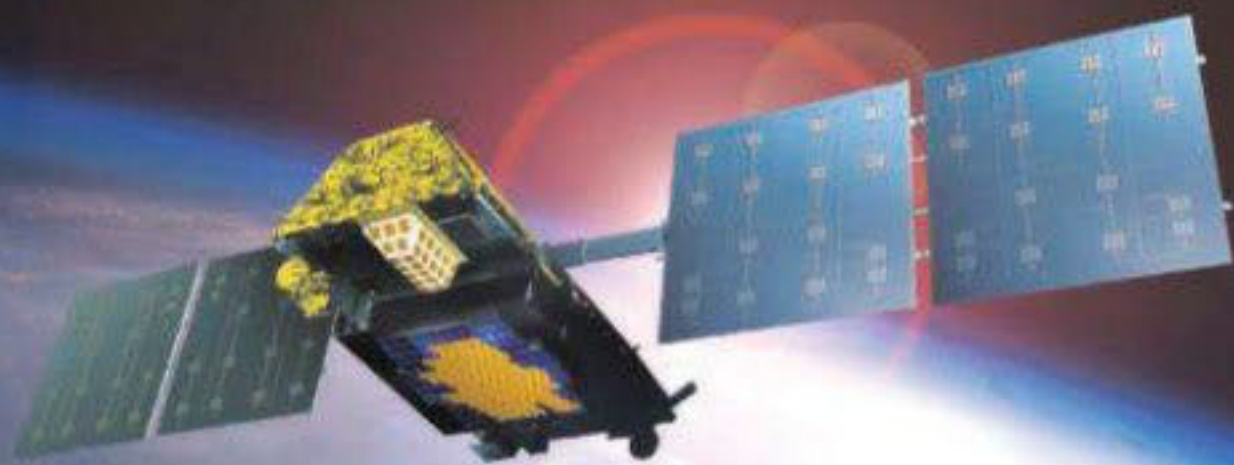
Along with asking the FCC for its own AMSS-R spectrum, as a backup option Arinc was also in negotiations with Inmarsat. In its FCC petition, Arinc was asking for a license to transmit air traffic control, AOC, emergency messages, aeronautical administrative communications (facilities status) and air-to-ground passenger communications from the cabin, a novel idea that Delta Air Lines had begun offering through the Airfone terrestrial service.

AMSS-R, however, was evolving in that time period. In 1982, NASA has asked the FCC to create a Mobile Satellite Service (MSS) that would use satellites to relay radio signals to and from mobile units, including communications to and from aircraft over the ocean or in remote areas. The FCC formally launched MSS in a 1985 notice of proposed rulemaking, calling for reallocating existing frequencies from the ultra-high-frequency and L-band for MSS. The FCC later decided to locate MSS entirely in the L-band, which it would share with AMSS-R.

Arinc’s request for an AMSS-R license in 1987 was a victim of that change. The FCC dismissed “without prejudice” Arinc’s application in part for “failing to conform” with the new MSS allocation decision and in part because its “non-safety-related” passenger air communications could not be offered under the existing AMSS-R classification.

The company that eventually won the MSS license in 1989 was the American Mobile Satellite Corp., which later evolved into LightSquared, a satellite communications provider. LightSquared lost a battle with the FCC in 2012 to introduce new terrestrial broadband services that would have severely disrupted the GPS signals that aircraft (and many other forms of transportation) use for navigation.

Arinc, which had appealed the FCC’s decision and lost, then began its relationship with Inmarsat, thus Balkanizing a communications chain that could have been a seamless airline-owned operation.



Iridium's satellites will host the ADS-B system, which is the white oblong shape on the satellite's underside.

vulnerable to power outages and intentional disconnection, the EU paper notes.

Data from the Aireon network will be processed by U.S.-based Exelis and supplied to ANSPs that have service contracts. However, Kellar says other types of users, such as airlines, could leverage Aireon for fleet tracking rather than air traffic control. "Provided security issues do not present [a concern], it does not necessarily have to be only ANSPs that subscribe," says Kellar. A service "that would enable airlines to sign up to receive signals for their fleet is something we are looking seriously at right now. Discussions with airlines in this area have been very encouraging."

So far, the ANSPs that have signed up for Aireon are focused on surveillance of Atlantic oceanic airspace. In addition to Nav Canada and Iridium, ANSP investors include Italy's ENAV, Denmark's Naviar and the Irish Aviation Authority. Nav Canada plans to gradually boost its shareholding to 51% by 2018.

More ANSPs are likely to join either as investors or customers. The FAA, for example, is expected to subscribe to the service. Kellar says "positive discussions" are being held with potential partners from other regions who would expand Aireon's use beyond the Atlantic. Announcements regarding these talks are expected shortly, says Kellar.

After the initial satellites launch in 2015, testing of the space-based ADS-B system could start in either that year or the next, Kellar says. There will be "good opportunities" to test the Aireon signals against ground-based ADS-B networks even before the rest of the constellation is deployed.

Full global surveillance capability is expected to be achieved in 2017, although further testing and validation will be needed. Nav Canada expects to begin operational service with Aireon in early 2018, and the benefits of improved oceanic surveillance—such as reduced separation and less restrictive routing—will be phased in gradually on the busy transatlantic routes.

Aireon will not necessarily render existing ground-based ADS-B or radar networks obsolete. Space-based ADS-B is regarded as being well-suited to vast areas of less busy airspace, while ground-based ADS-B is better able to handle high-density domestic airspace.

Kellar says Aireon is designed for areas of moderate density. It can track 1,000 active targets within the span of one satellite footprint, which is about 2,000 nm in diameter.

However, he emphasizes that the system's capability is not confined to oceanic airspace. "We anticipate that Aireon will also be used as a backup in domestic airspace and as a replacement or substitute for ground-based surveillance in domestic areas of moderate density."

Since space-based ADS-B is a new technology, various regulatory authorizations will be required. The Canadian government must grant approval for Nav Canada to use it for air traffic control purposes. In addition, "ICAO support and direction to member states on this matter is important to facilitate the necessary approvals in individual jurisdictions," says Kellar.

Action is also required from the International Telecommunications Union (ITU) to protect the 1090 MHz frequency. It is already protected for air-ground communications, but the ITU would need to change the documentation to cover satellite-to-aircraft communication. ICAO has asked the ITU to consider the necessary changes at its next meeting in 2015. ☛

Orbiting Eyes

Aireon venture expands potential of ADS-B for aircraft tracking

Adrian Schofield

A new satellite-based system that is intended to provide the first surveillance coverage of oceanic airspace could also play a major role in improving global aircraft tracking during emergencies.

The Aireon system, currently under development, relies on automatic dependent surveillance-broadcast (ADS-B) technology. However, instead of using ground-based ADS-B stations as current networks do, the receivers will be housed in satellites. This means they can provide coverage beyond the limited range of ground-based receivers.

The primary aim of Aireon is to supply surveillance data to air navigation service providers (ANSP) that subscribe. This would allow more direct air traffic control for aircraft in remote airspace, with significant gains in efficiency and safety. While Aireon is not the only space-based ADS-B system being developed, it is the most advanced. Other competitors include Thales Alenia Space and Globalstar.

Some of the same limitations of ground-based ADS-B systems would still apply to the space-based version—for example, aircraft cannot be tracked if transponders are turned off. However, it is clear that Aireon offers a step change in the global aircraft surveillance capability.

The Aireon ADS-B payloads will be hosted by Iridium's next-generation satellite constellation that is due to be launched starting in 2015. Iridium has sought to enlist ANSPs to be customers and investors in the Aireon venture, and Nav Canada has become its major partner. Nav Canada plans to use the system for surveillance coverage of the North Atlantic beginning in 2018.

Aireon can help answer calls for improved tracking solutions, as it will "provide the ability to track any ADS-B-equipped aircraft anywhere in the world," says Rudy Kellar, Nav Canada's executive vice president for service delivery.

Aviation regulators also believe Aireon has a great deal of potential in this regard. In a paper presented to a recent International Civil Aviation Organization (ICAO) summit on global tracking—prompted by the disappearance of Malaysia Airlines Flight 370 (MH370)—the European Union included space-based ADS-B as one of the options that should be considered.

Among the advantages of such systems cited by the EU is cost-efficiency for airlines. There is no need for additional equipment if aircraft already have a transponder that works with traditional ground-based ADS-B networks. ADS-B positions are also extremely accurate, although transponders remain

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Lock and Locate

Meosar taking the 'search' out of search and rescue

John Croft **Greenbelt, Maryland**

The combination of a new search-and-rescue satellite network and second-generation emergency locator transmitters will soon transform the way distress signals are activated and detected and then generate responses.

Set for initial operation in 2018, the Mid-Earth Orbiting Search and Rescue System (Meosar) will take advantage of signal repeater payloads on as many as 72 satellites in three navigation satellite networks—GPS, Galileo and Glonass—to relay distress signals from 406-MHz emergency locator transmitters (ELTs) to ground stations within seconds. By design, Meosar will eliminate position-fix lags that can range from 45-100 min. with the existing Cospas-Sarsat network of five low-Earth-orbit (LEO) satellites and six geostationary (GEO) satellites.

Equally game-changing are the second-generation ELTs that NASA and industry are now defining for introduction after 2016, devices that will have several new operating

The so-called 7th arc highlights a large swath of the southern Indian Ocean where crash investigators believe Malaysia Airlines Flight 370 lies.

modes to help ensure that a distress signal actually is transmitted. Included are flight attitude triggers that are designed to cause the unit to send out a distress signal before a crash, and "return-link" service that could allow an external control center to activate the unit remotely, based on concerns about the behavior of the flight. Advance notice of the position of a potential crash will give rescue coordination centers a jump on dispatching crews to the scene, and ultimately aid in the timely retrieval of the flight data and voice recorders.

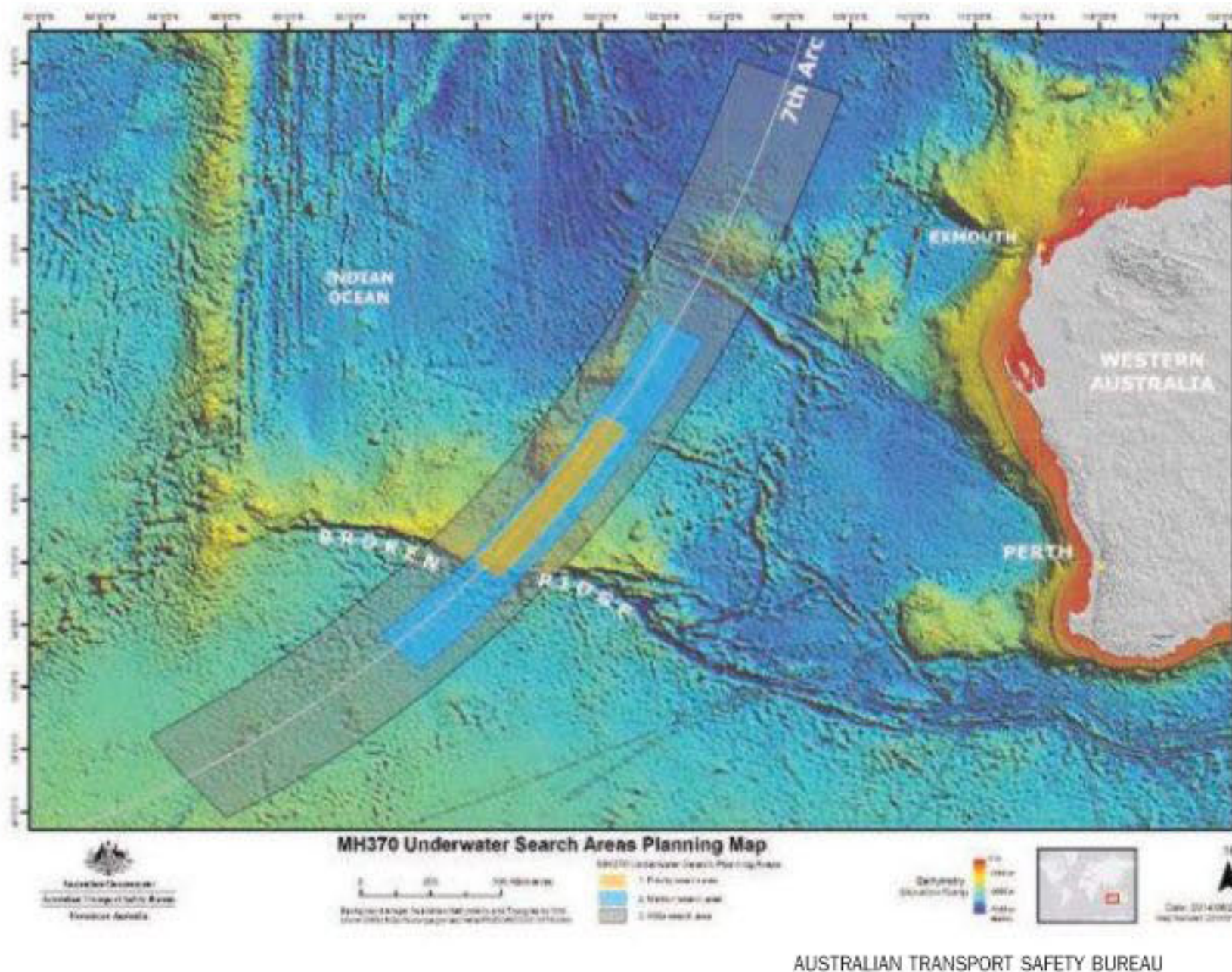
The evolution was set in motion more than a decade ago but accelerated by delays in locating the wreckage after the Air France Flight 447 crash in June 2009. The disappearance of Malaysia Airlines Flight 370 in March is increasing pressure to make the new network and ELTs operational.

Engineers at NASA's Goddard Space Flight Center here, the research and development arm for the U.S. portion of the international Cospas-Sarsat program, have been preparing the spaceborne and ground segments of the Meosar program since the early 2000s with \$30 million in NASA funding. Cospas-Sarsat was formed by the U.S., Canada, France and Russia in 1979 to support the search-and-rescue functions of the International Maritime Organization and International Civil Aviation Organization (ICAO). Now joined by 42 other nations, the organization says it has saved more than 35,000 lives based on rescues carried out when distress beacons were activated.

The ground segment includes local user terminals, or

ground stations, mission control centers (MCCs) and rescue coordination centers. For Meosar, the local user terminals (Meoluts) compute the location of the 406-MHz distress beacon. Techno-Sciences, a subsidiary of the McMurdo Group, delivered the first Meolut to NASA Goddard for testing with the prototype on-orbit system in 2006. Jean-Luc Abaziou, CEO of Techno-Sciences, says the two Meoluts that are needed to cover the U.S. are already in place, one in Hawaii and one in Florida.

NASA's funding in part paid for 14 prototype Distress Alert Satellite System (DASS) payloads flying on 14 Block 2F GPS satellites. While not the same as the operational Meosar payloads (DASS uses a different downlink frequency), DASS "made sure we could work with the mid-Earth network and that it would be much better than LEO," says Lisa Mazzuca, a Goddard astrophysicist and mission manager for NASA's search-and-rescue office. "We build 'first-offs,'" says Mazzuca. "As the technical arm, we are the ones that develop all of the prototypes. Everything is done here first



before it ever sees the light of day at the operational level."

Currently two of the four Galileo satellites are carrying operational L-band Meosar payloads, both of which have a return-link capability, although one of the satellites failed for unexplained reasons in May. Engineers have successfully tested the return link with prototype ELTs. There is also one operational Meosar repeater on a Glonass satellite.

The first of the new repeaters on GPS satellites will come with the Block 3 GPS, which is set for launches to begin no sooner than 2020, says Mazzuca, adding that initial operations will largely use Galileo and Glonass units. The Block 3 GPS constellation, when built out, will have at least 24 satellites, which eventually will be complemented by 27 Galileo and 24 Glonass satellites with search-and-rescue repeaters, for a full constellation of at least 75 satellites.

The second-generation ELTs will not be required to work with the Cospas-Sarsat network, although first-generation ELTs will be compatible with Meosar. Mazzuca says this Leosar constellation will be phased out after a period of overlap

with Meosar, but the Geosar capabilities will be maintained.

NASA's latest efforts are aimed at finalizing performance standards for the second-generation ELTs to include pre-accident automatic activation, as part of the government and industry RTCA Special Committee 229 team. ELTs come in three main types—hand-carried personal locator beacons (PLBs), ship-mounted emergency position-indicating radio beacons (Epirbs) and aircraft-specific ELTs—all operating in the 406.0-406.1-MHz protected-frequency band. NASA says there are 1.42 million ELTs of three main types in operation: 650,000 Epirbs, 520,000 PLBs and 250,000 ELTs. Abaziou says the Cospas-Sarsat ground segment includes 56 LEO satellite local user terminals (Leoluts), 22 Geoluts and 30 mission control centers around the world.

Among aircraft ELTs, ICAO defines three types that can be used for international flights: automatic-fixed, automatic-portable and survival. The automatic-fixed ELT is permanently mounted in the aircraft, as far aft as possible, and has a G-switch that activates the device when a certain acceleration is applied to indicate a crash. Pilots also can manually activate the ELT using a switch in the cockpit. An automatic portable ELT is attached to the aircraft, but can be removed when the pilots evacuate; a survival ELT is portable and automatically activates when coming into contact with water. Although the FAA does not require U.S. scheduled airlines to carry an ELT, Europe and other countries follow ICAO rules for search and rescue, which requires U.S. aircraft on international routes to be equipped. For aircraft with more than 19 seats built after July 1, 2008, ICAO requires two ELTs, one of which must be automatic-fixed. For legacy aircraft, the rules require that one ELT of any type be carried.

When activated, a distress beacon emits a 406-MHz burst for 0.5 sec., repeating every 50 sec. until the battery dies, typically for around 150 hr. ELTs also include a 121.5-MHz homing beacon that searchers use to find the aircraft upon arrival in the general area. NASA is studying whether first responders can use the 406-MHz signal for homing, eliminating the 121.5 beacon and reducing the cost of both the ELT and first responders' homing receivers.

Engineers originally selected the 50-sec. timing interval between 406-MHz bursts because it maximizes the frequency change measured by the polar-orbiting satellites versus the time of closest approach to the beacon, minimizing the time it takes to calculate the position of the beacon.

The Doppler method is not without drawbacks, however, as it can take two satellite passes to resolve a location. The satellite stores the beacon data and, once in view of a Leolut, downlinks the information on a 1,533-MHz protected band. The Leolut, which operates autonomously, processes the information using the Doppler shift and calculates a location, sending the data to MCCs in member countries and regions near a crash site. The MCCs contact various rescue coordination centers for dispatching search-and-rescue teams. Second-generation ELTs will not be tied to the 50-sec. repeat time, allowing for a faster position fix—preferably while the aircraft is in the air—and methods of increasing battery life after a crash.

For both AF447 and MH370, no distress beacon signals were picked up by Cospas-Sarsat. Investigators of the Air France crash used Aircraft Communications Addressing and Reporting System-generated position and housekeeping updates to determine a 5-min. window of uncertainty around the aircraft's track. With a ground speed of 480 kt. that translated to a disk-shaped search area with a 40-nm

radius centered on the last known position, which was 500 nm from the coast of South America. Compared to MH370, for which the latest search area is 60,000 sq. km., the Air France search area was miniscule, but it required two years to find the main wreckage and flight data recorders.

In the final report on AF447, the French civil aviation accident investigation bureau, BEA, recommended that ICAO and the European Aviation Safety Agency look at the possibility of activating an ELT "as soon as an emergency situation is detected on board." The Malaysian Boeing 777-200ER reportedly had a fixed ELT, a removable ELT in the cabin and two in a life raft, none of which was heard from.

Reliability of the devices has been in question for some time. According to an ICAO report from 2010, ELTs have a "false negative" rate of 57%, "which is unacceptably high" although officials say the sample size of about 20 accidents per year, for which ELT information is included, is too small for meaningful metrics. The annual number of civil-aircraft accidents where an aircraft is destroyed is approximately 400. Along with calling for studies of the reliability of ELTs, which often fail when the external antenna disconnects from the base unit, ICAO wants better reporting of ELT performance in all crash investigations to gain a better insight into reliability. NASA is studying the issue and plans to run unit-level tests in September and a full-scale helicopter crash test in 2015.

Even if an ELT does activate before or after a crash and the signal is picked up by a satellite, the wait time for a position fix with the existing LEO system can be as long as 100 min., as resolving the position using the Doppler method alone can take multiple passes. Help is often available from the GEO satellites, which can detect distress beacons at latitudes of less than 70 deg. almost instantaneously. However, since the GEO satellites are not moving relative to the Earth, Doppler measurements are not available and the system can only provide a position fix if the ELT transmits GPS position, an option that allows for a position fix within a radius of 120 nm but adds to the cost of the ELT. According to NASA, about 50% of the 1.42 million active beacons have GPS encoding.

By placing repeater payloads on dozens of GPS, Galileo and Glonass medium-altitude satellites, a first-generation ELT beacon activated anywhere on Earth will be immediately picked up by at least four satellites, which will relay the information to Meoluts. Computers in the Meoluts will use "reverse triangulation" to calculate a position fix based on the difference in the frequency and time of each repeated signal, reducing the average radius of the fix location to 0.9 mi. with Meosar from 1.7 mi. with the LEO constellation, with a location estimate provided within 5 min. NASA hopes to reduce that position estimate to as little as 300 ft.

With the new constellation, engineers are also able to redesign the ELT itself, in part to fill the gaps exposed by AF447. Though U.S. and international partners continue to debate the final specifications for the next-generation ELT, some enhanced parameters are given. Included are triggers from the flight deck that will automatically activate the unit; a faster repeat cycle for the 406-MHz bursts, particularly when first activated; a return-link service that can be used to remotely activate or deactivate the system, a feature that can be used to track an aircraft in flight using Meosar, and the ability to dynamically change the repeat cycle using the return link in order to significantly extend battery life after first detection and before the first responders arrive. ☛

Call to Action

MH370 disappearance increases pressure for streaming data and deployable recorders

John Croft **Washington**

The airline industry appears to be gravitating toward two midterm solutions for global flight-tracking since Malaysia Airlines Flight 370 (MH370) went missing in March. Individually or together, triggered flight-data transmissions and deployable flight recorders could quickly determine an aircraft's location and basic health, pre- or post-incident.

Both technologies are available today and were highly touted in the aftermath of the crash of Air France Flight 447 in June 2009, when it took five days to find wreckage and nearly two years to

are spring-loaded into a compartment in the exterior of the aircraft and ejected outward if certain flight conditions or force parameters occur indicating an unrecoverable attitude or crash force. The military has been using deployables since the 1960s, but Van den Heuvel says that although approved specifications for building deployable recorders have been available since 2007, "no aircraft [maker] or operator of air transport aircraft has taken advantage that."

The reticence could change as safety advocates weigh in post-MH370 and



recover the recorders. Despite renewed pressure to act following MH370's disappearance, neither technology is yet considered a "near-term" possibility, primarily due to the cost and time to retrofit the equipment into legacy fleets or build up substantial numbers of factory-equipped new aircraft.

"The ironic thing is that in the search for MH370, there were Australian P-3s, a Japanese P-3, an Indian P8I, Sea King and Sea Hawk helicopters, all fitted with deployable recorders," says Blake van den Heuvel, director of air programs for DRS Technologies, which has approximately 5,000 deployable recorders in service, most in military or search-and-rescue aircraft.

Deployables, which contain an integrated flight data recorder (FDR), cockpit voice recorder (CVR) and emergency locator transmitter (ELT),

airlines develop longer-term plans that will likely include international mandates and rule changes. The Flight Safety Foundation came out in early July in support of deployables first, and triggered flight data as an alternate. "We have the technological capability and with several high-profile events, including Air France 447 and Malaysia 370, there is clearly the need for a better way to retrieve the flight data information immediately following an accident," says FSF President/CEO Jon Beatty.

Triggered flight data involves sending bursts of flight recorder data through satellite links to airline operational control (AOC) centers when a predetermined anomaly condition occurs or the pilots activate the system. "At the operations center for a major airline, you're looking at a massive board all around the world, with 50 or



Interactive See more about DRS's deployable technology and some aircraft that carry it. Tap here in the digital edition, or go to AviationWeek.com/ADFR

60 aircraft out there," says Matt Bradley, president of streaming data provider Flyht Aerospace Solutions. "If one [aircraft] disappears, it's 'Where's Waldo?'" Flyht uses the Iridium constellation of low-Earth-orbiting satellites to provide global coverage for voice and data. Competitors for flight data streaming include Star Navigation Systems, Panasonic's FlightLink and Honeywell's Sky Connect Tracker.

AF447 crash investigators noted that the Air France dispatchers would see an orange visual warning in a displayed list of Air France flights whenever position reports, issued every 10 min., revealed an aircraft to be more than 30 nm off its intended course, or if no position reports had been received for 30 min. An aircraft at cruise speed travels approximately 8 nm per minute.

Flyht's automated flight information reporting system (Afirs), in use by 30

Flyht's monitoring system for airlines increases the data rate from an aircraft in distress while alerting dispatchers in the control center.

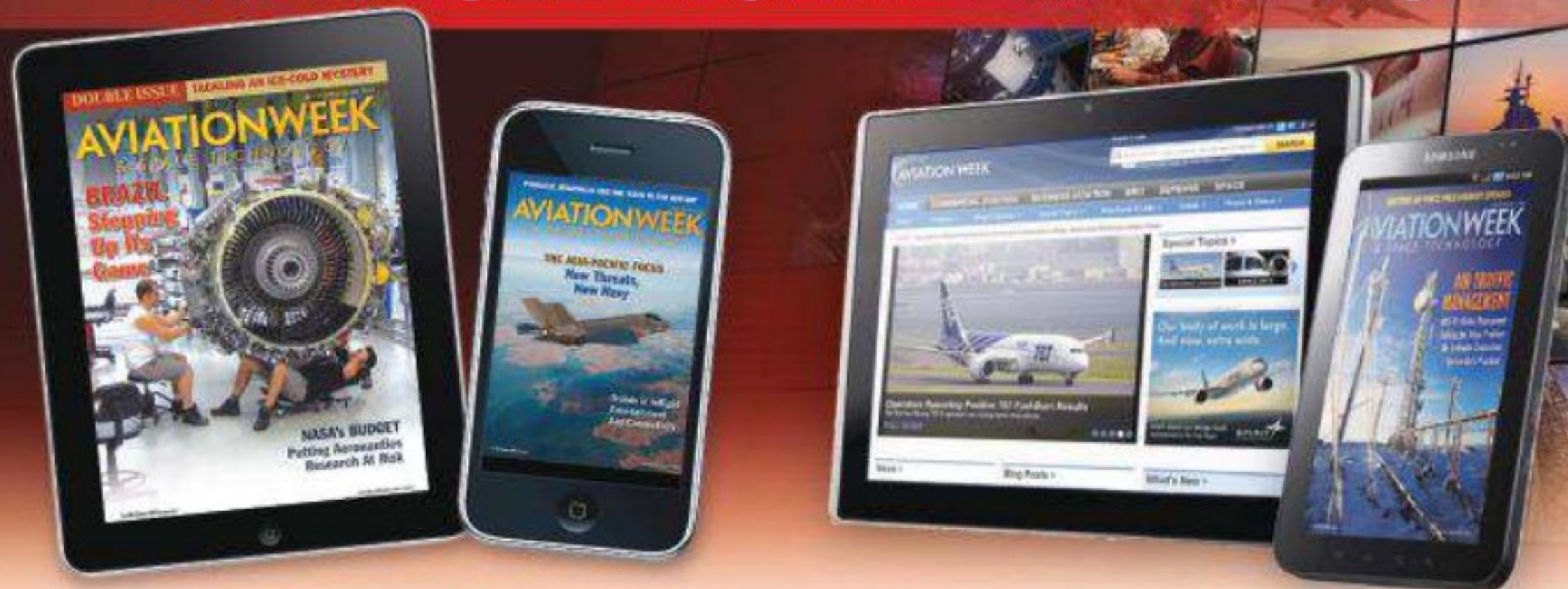
airline customers, includes a FlyhtSafe option with a visual and audible alert to dispatchers when automatically triggered by conditions such as excessive pitch and bank angle, excessive speed below 10,000 ft. or excessive descent rate. In normal mode, Afirs provides the AOC aircraft position information at regular intervals, typically 5 min. apart, and in alert mode, it sends selected flight recorder parameters every 20 sec. or less, leading to position reports roughly every 2.5 nm traveled at cruise speed. "There's an alarm, an aural alert, and the situational display centers on that aircraft," says Bradley. "There can be no mistaking it."

The alarm is followed by burst mode data, which includes flight parameters in the present and for several minutes or more in the past, for forensics. Bradley says "a number of airlines" use the alerting function in daily operations, with pilots activating a discrete "event" button that communicates "look at me" to the dispatchers to increase situational awareness. "We tell the pilots don't be afraid of the button," says Bradley. "Use

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it if you're low on gas and approaching minimums, which means you might have to go to your alternate."

The U.S. House of Representatives in May called on the FAA to support efforts to evaluate the costs and benefits of installing automatic deployable flight data recorders as part of the International Civil Aviation Organization's (ICAO) ongoing effort to identify and implement "international standards to help avoid the circumstances that have surrounded the disappearance of MH370." The floating, self-contained devices generally include a copy of the FDR, CVR and an ELT that signals the Cospas-Sarsat rescue system to locate the distress beacon (see [page 44](#)).

And float they do. In 2005, a U.S. Navy F/A-18 crashed when attempting to land on the USS Kitty Hawk off the coast of Japan. The DRS deployable recorder ejected as designed and floated for five years until a surfer in Hawaii came upon it on the beach. The Navy had not been seeking the recorder, as it had all the evidence it needed to investigate the crash, which left the crew uninjured and the aircraft at the bottom of the ocean. "The box came back to Navy safety group in [NAS] Patuxent River [Maryland] and they recovered the data," says van den Heuvel. He says DRS deployables have been involved in approximately 120 catastrophic events with civil and military rotary and fixed-wing aircraft, with a 95% success rate of being able to recover all the data. For air transport-type aircraft, he says the success rate is 100%.

Starting in 2016, new aircraft with a takeoff weight over 33,000 lb. will require combination (combi) recorders per new ICAO standards. The solution is to have two combi recorders, one at each end of the aircraft, capturing all flight and voice data. Assuming states adopt those rules, the action will give a boost to DRS and a handful of other deployables competitors, including Airbus Cassidian and GE Aviation.

However, ICAO's Flight Recorder Panel is proposing that the recorder in the back of the airplane be a deployable, rather than both recorders being fixed to the airframe. "There is no point to having two standard type recorders go to the bottom of the ocean or be lost in a remote area of the world," says van den Heuvel. ICAO's Air Navigation Bureau will discuss the proposal in September.

Both deployables and streaming-recorder options were identified in late

How a Deployable Flight Recorder Works

1. Sensors detect the start of a crash.
2. Deployable unit releases from aircraft.
3. Deployable unit lands safely away from crash site on land or in water, where it can float indefinitely.
4. Emergency Locator Transmitter (ELT) transmits location and ID of aircraft emergency beacon via satellite to search-and-rescue authorities.
5. Deployable unit acts as homing device for rescue crews.
6. Search-and-rescue personnel recover survivors and deployable recorder.



DRS TECHNOLOGIES

2009 as the highest-ranking technologies for accelerating flight data retrieval by an international flight data recovery working group. Neither was considered "near-term," though. The group found that triggers for setting off streaming flight data were not yet mature, in part related to false alarms, and that retrofit costs for deployables were high compared to installations in new aircraft, in part due to certifying the equipment on each new aircraft type. Today the triggers are more mature, but costs continue to be a challenge.

Van den Heuvel says nearly 70% of the DRS deployable installations to date have been retrofits, where hardware costs roughly \$30,000 and installation time is 100-120 hr., once the supplemental type certificate is in hand.

For a new-design aircraft, he says the cost differential between installing two combi recorders versus one combi and one deployable is nil.

Bradley says retrofit installation costs for Flyht are \$50,000 for equipment and \$50,000 for installation, which takes 175 hr. and is generally done during a "C" maintenance check.

Both companies expect a positive affirmation of their technologies once the government and industry Aircraft Tracking Task Force makes its recommendations to ICAO in September. Launched by the International Air Transport Association in April following MH370's disappearance, the task force is developing performance-based standards that airlines use to track their aircraft.

Cloud Cover

Shared computing could provide long-term solution to global flight monitoring

Graham Warwick *Washington*

Clinging conservatively to its legacy computer systems, the aviation industry is being slow to embrace the cloud. But the shared computing paradigm could be the long-term answer to the problem of global flight tracking and real-time data monitoring.

It is time for airlines to take advantage of the cloud, says Darrell West, founding director of the Center for Technology Innovation at the Brookings Institute, a public-policy think

tank in Washington. "Many public and private sectors today are using cloud computing to store data in real time. This allows people on the other side of the planet to track what is happening and analyze problems," he says.

"In the case of catastrophic failure, the data are not lost," West says. "Airlines should outfit aircraft to automatically transmit information on flight location, speed and operations to file servers on land through tamper-proof

mechanisms. Aviation authorities can use this information to monitor flight conditions and, in the case of problems, recreate the flight situation that led to air crashes."

The concept of using an aviation cloud was raised at the "Expert Dialogue" on real-time monitoring of flight data held in Kuala Lumpur in May, in the wake of the March disappearance of Malaysia Airlines Flight 370. The meeting urged the International Civil Aviation Organization (ICAO) and International Telecommunications Union (ITU), both agencies of the United Nations, to begin work on developing performance-based international standards for an aviation cloud.

In addition to ensuring that critical data are immediately available in the event of an aircraft accident or disappearance, storing flight data in a cloud would allow users to apply data analytics and data mining to improve the information available to travelers as well as the operational and environmental efficiency of the aircraft.

seek to exploit cloud computing and "big data" analytics, including the health care, utilities and automotive industries.

The Expert Dialogue recommended that ICAO develop the minimum requirements and concept of operations for real-time monitoring of flight data, work with ITU to determine the communications standards and spectrum requirements, and together estimate the cost impact and develop business models to make it affordable.

The meeting called on ICAO and ITU to identify the standards, policies and regulations needed, including studying requirements on data protection and ownership, information security and privacy, and appropriate use of data. The organizations were also asked to lay out a road map of events and decisions leading to implementation.

In response, ITU has established a "focus group on aviation applications of cloud computing for flight data monitoring," shortened to FG AC. The group is charted for a year from its

mechanism to develop international standards to make streaming interoperable and affordable.

Flight-data downlinking is available now from several vendors, using lower-bandwidth satellite communications, but it is not standardized, says Christian Dumas, vice president for commercial aviation at satcom provider Inmarsat. He believes Inmarsat's SwiftBroadband service, when approved for safety services in 2015, will remove any technology limitations on a "black box in the cloud."

Next-generation cloud-based flight data recording is not a technical problem; the challenges are procedural and regulatory, Nis Herzberg, global sector head for discrete industries at enterprise software company SAP, told the Expert Dialogue attendees. Issues include who will own the data generated by the aircraft, and whether operators' "traditional" ownership rights to flight data can continue.

In a cloud scenario, other key questions are who will be a trustworthy



BOEING

But while inflight streaming of data is possible technically, many institutional issues must be addressed first. These revolve around the type of data to be transmitted; whether it is streamed continuously or triggered by an event; transmission rates and communications spectrum requirements; security of the data, its integrity, availability and authenticity; and avoiding potential misuse of the data.

The growth in commercial broadband services to the aircraft cabin and the drop in communication costs with the latest generation of high-throughput satellites raises the possibility of using some of this capacity for flight data, although there are concerns about safety and spectrum allocation.

But the questions being raised are not unique to aviation and are similar to challenges being tackled by other sectors worried about reliability, liability, safety and security as they

first meeting, scheduled for Dec. 1-3 in Kuala Lumpur. Within the ITU, focus groups are created for the rapid development of specifications to address industry needs as they emerge. Usually short-lived, they have greater freedom to organize and finance themselves than the technical study groups that develop standards.

Based on operational requirements to be established by ICAO, the FG AC is charged with identifying the communications standards needed to establish an aviation cloud for real-time monitoring, to include data protection and security, ownership and access.

Specific tasks include compiling information on current and future cloud computing, developing use cases on how analytics and mining techniques could be applied to flight data in a cloud, reporting on the feasibility of using commercial broadband for data streaming, and proposing a

Russia is proposing that aircraft be equipped to share and store data via a self-organizing airborne network.

data custodian, where will the data be kept and which privacy legislation will apply to the stored data. A crucial issue is how to prevent access to the data for litigation purposes, he says, noting that U.S. nationals can demand access to foreign-owned data stored in U.S. data centers.

Access rights are another issue, particularly in terms of how owners could obtain their data for use in condition-monitoring and performance benchmarking, and how operators, manufacturers and regulatory authorities would gain access to flight data for forensic analysis, he says. But SAP believes there can be additional value for owners, operators and manufacturers from real-time data streaming. ☛

Off The Shelf

Smartphone advances are shaping fast small-satellite development

Frank Morring, Jr. **Washington**

Terrestrial smartphone technology, based in part on government space research, is finding its way back into space as low-cost, rapidly evolving processors, cameras, GPS receivers and other gear used in bulk by the burgeoning smallsat movement.

In California's Silicon Valley, where the lifetime of a state-of-the-art smartphone is about one year, engineers at NASA's Ames Research Center have literally been plugging smartphones into spacecraft to get the most capable hardware into space quickly.

That approach has migrated into the commercial sector, where groups of Ames alumni are applying it to constellations of low-orbit smallsats that they are evolving toward the day when they can provide daily remote-sensing updates over the entire Earth.

Space Labs' tiny "Dove" spacecraft, shown shortly after deployment from the ISS, draw on advances in consumer electronics.

"We don't actually use any phones anymore, but we do use consumer electronics, and all the chips that are in phones," says Will Marshall, one of the founders of Planet Labs Inc. and a veteran of NASA's PhoneSat project at Ames. "We go right to the core and design all our own circuit boards, it's all our own technology. But we leverage all the transistors and the radio components and the amps and the resistors, we leverage all the developments that are happening. We take the latest CPUs [central processing units], the latest flash drives, the latest sensor systems and stuff [them] into our little box."

That approach has attracted the attention of the venture capitalists and angel investors on Menlo Park's Sand Hill Road, the Wall Street of Silicon Valley. So far, Space Labs has raised \$65 million and launched 71 of its tiny "Dove" satellites. Competitor Skybox Imaging had raised more money, but launched fewer of its larger satellites, when it was acquired by Google in June for \$500 million (*AW&ST* June 16, p. 34).

NASA Ames has been an incubator for the technology turnaround, pulling technology originally developed for traditional "big" space back into the small-space arena after it was adopted and mass produced by the private sector. Smartphones are the nexus of the shift, and it started at Ames.

Marshall, who is CEO of Planet Labs, remembers one of his NASA bosses at Ames waving his cellphone around during meetings about spacecraft design and asking "Why are you guys making it so complicated? You



have everything you need for a satellite in this smartphone."

"Eventually we took him seriously," says Marshall of the PhoneSat project.

The first PhoneSat was literally just that—an off-the-shelf smartphone launched into space inside a 1U cubesat.

"They picked a phone that uses open-source software [a Nexus One running Android], which they felt has the potential for allowing multiple sources of application software," says Andy Petro, program executive for NASA's Small Satellite Technology program in the Space Technology Mission Directorate.

The Phonesat 1.0 configuration ran on battery power, and used the phone's camera to photograph Earth for the week that it lasted in space after its April 21, 2013, launch on the first Orbital Sciences Antares launch vehicle

to fly (which also carried the first Dove for Planet Labs). The spacecraft famously used a length of yellow tape measure as its UHF radio antenna.

"For the 2.0 version they took the electronics out of the mobile phone box and build it up a little bit more like a series of circuit boards inside the cube," Petro says. "We immedi-

PLANET LABS INC.



A Planet Labs image taken July 1 shows the low water level in a reservoir in drought-stricken Minas Gerais, Brazil. The company's goal is to provide daily updates, worldwide, to allow near-real-time responses to fast-moving changes on the surface.

ately had contact with it after launch.”

That spacecraft was among 28 cubesats launched in November 2013 as secondary payloads on an Orbital Sciences Corp. Minotaur vehicle. Equipped with solar cells to recharge its batteries, the spacecraft worked well at first, but lost functionality later in its mission. Petro says radiation effects are the suspected cause, but the issue is still under study.

The same types of problems cropped up on PhoneSat 2.5, which was launched on a Falcon 9 from Cape Canaveral in April. That spacecraft includes a rough pointing capability provided by reaction wheels driven by small electric motors the project acquired from a dental-drill supplier.

Smartphones have supported other space applications recently. They include robotics experimentation inside the International Space Station using the Synchronized Position, Hold, Engage, Reorient, Experimental Satellites (Spheres) testbeds. Crewmembers on board the station have used the “Smart Spheres” to evaluate robotic systems that could one day drive free-flying “helpers” to take over routine maintenance chores from humans.

Basically a set of basketball-sized spacecraft powered by compressed gas, Smart Spheres are used to test various guidance, navigation and control software packages uploaded from the ground for testing. But the processors in the Spheres units are too old to handle advanced robotics software efficiently.

“The processing power on Spheres as a core system is something that has been around quite a long time now, probably 10 or 15 years, not nearly powerful enough to run the kinds of robotics software algorithms we take for granted on every other robot platform in the world today,” says Terry Fong, who runs the Intelligent Robotics Group at NASA Ames. “So our approach for addressing these limitations of Spheres as a legacy system was to add a smartphone to it. Just over three years ago we upmassed the Google Nexus S, an Android-based smartphone. It gives us a lot of computational horsepower in a small package.”

The phone was literally kluged onto the side of one of the Spheres units (see photo), bringing along its 1-GHz Cortex A8 processor, 512 MB of RAM, a 16-GB flash memory, 3-axis gyros and accelerometers, and two color



Astronaut Mike Fossum works with a “Smart” Sphere testbed on the ISS, upgraded with an off-the-shelf Samsung Nexus S smartphone (inset).

cameras. Fong and his team used that capability to study the use of Wi-Fi signal strength inside the station as a way for a robot to navigate autonomously through the modules.

The project already has outgrown that capability. Now the group is planning to use a Google “Project Tango” prototype with a structured lighting sensor drawn from X-Box Connect technology to improve the robot’s ability to find its way around.

“If any of you remember the Nexus S, it was state of the art about four years ago, and then it was not state of the art about three years ago, which is sort of a lifetime in the smartphone world,” Fong told an ISS utilization conference in June.

At Planet Labs, the philosophy is to launch early and launch often, building in upgrades with each “flock” of the Dove spacecraft it sends to orbit and testing them there. The 28 Doves launched on an Antares July 13 for deployment from the “porch” of Japan’s Kibo module (see [page 19](#)) were “Build 8” in the Planet Labs design sequence, while the 11 launched on a Russian Dnepr repurposed intercontinental ballistic missile June 19 were the “Build 9” variant. With the ultimate objective of a nanosat constellation able to update overhead imagery of every point on Earth every day (see photos), the company has moved on to Builds 10 and 11 since those launches, Marshall says.

“We think there are strong humani-

tarian uses for this data and strong commercial uses,” says Marshall. “Imaging having the data soon after flooding or fire, or earthquake, or the plane crash in the Ukraine. If we can have that data, we can help those relief operations faster. And we also have the data from the day before. One of the things we saw in Haiti and the tsunami in Japan is that people scrambled to get imagery in the immediate aftermath of the disasters, but no one had the image from the day before, and it turned out Haiti had changed a lot since the last image taken of that area [was several years ago]. We would be able to have an apples-to-apples comparison.”

One issue Planet Labs, Skybox and others will have in controlling the data flow from space may be helped by the next phase of the PhoneSat effort at NASA. Known as the Edison Demonstration of Smallsat Networks (EDSN), the idea is to launch eight 1.5U cubesats designed to handle communication with the ground autonomously.

“You’ve got a bunch of small satellites, each taking science measurements,” says NASA’s Petro. “Rather than having to have a ground system that’s talking to each of these satellites, which as you can imagine as you get beyond eight to dozens or a hundred, it’s really not so practical to do that. You lose the benefit of the low-cost mission if you need a huge expensive ground infrastructure to deal with them. So the idea is they each talk to each other, they share the data among themselves, and then one of them serves as the relay to the ground.”

The EDSN constellation, set to fly from Hawaii Nov. 14 on a rail-launched Super Strypi rocket, will measure radiation across space as a simple test of the inter-satellite link in scientific data-collecting. All of the spacecraft can collect and send data to the ground, and the cross-link architecture will allow an operational system to degrade gracefully, continuing to collect and send data until only one is left.

Marshall says he and other Planet Labs engineers were involved in early planning for the EDSN project, and are monitoring it for possible application in their own constellation. In the meantime, the company is upgrading its ground-station network as it evolves toward its daily update goal.

Planet Labs is located in San Francisco, where it can maintain close

contact with technology and business developments in the Bay Area. Petro, who is based at NASA headquarters in Washington, says that sort of technological churn between terrestrial and space applications in the private sector illustrates how spending on govern-

ment research and development can find its way into the broader economy.

"It was government investment over decades in the past that created this electronics technology we have now that makes possible all of these wonderful consumer products we all use,"

he says. "We can now go back and take advantage of that huge investment made in the past—coupled with the efficiency of the mass production for the consumer products—to get those very high-tech items at extremely low cost compared to typical prices today." ☛

Adding Up

Lockheed Martin is testing 3-D-printed subsystems on A2100 space bus

Amy Svitak Farnborough

For additive manufacturing, Lockheed Martin Space Systems started with small parts, mainly brackets used to support sensors and other instruments inside spacecraft.

Within the next three years, however, the company expects more than half of its A2100 satellite bus to be built through additive manufacturing, a revolutionary fabrication process that promises drastically reduced hardware development costs and production-cycle times.

Even without the benefits of so-called 3-D printing, the A2100 has seen a decrease in parts count by up to 60% in some subsystems, related to a technical refresh that has been ongoing since early 2013.

"On the antenna reflectors alone there were 3,600 manual operations, and that [number will be] going to zero on the new platform," says Richard Ambrose, executive vice president of the Denver-based company.

In parallel, however, Ambrose says they are working toward identifying ways to save money and time through additive manufacturing of key technologies incorporated into the A2100 space bus. For the moment, the percentage is low—less than 10%.

"But my goal is to have over 50% of the structures 3-D-printed within two to three years," Ambrose said in an interview on the sidelines of the Farnborough air show last month.

Already at least a dozen 3-D-printed brackets are flying in space aboard

NASA's Juno mission, a Lockheed Martin-built solar-powered spacecraft launched in 2011 on a six-year journey to the Jupiter system.

Ambrose says it can take 30 hr. to machine some brackets by hand, although additive manufacturing can produce 300 of the same part in a single day, all of which are as structurally sound.

For now, the A2100 propulsion system is the major focus of the company's additive manufacturing efforts, which aim to reduce production of fuel tanks from 18 months to a matter of weeks.

"I can print half a tank in three hours," Ambrose says, adding that the company has already pressure-tested one such article, with plans to conduct

a full-qualification burst test this year.

The next step, he says, is an electronic chassis; today, these are machined from aluminum.

"The alloys are different in 3-D printing, so we have to work through that and make sure we're getting the quality right in the structure," he says. "I'm told they're close to a solution."

Ambrose notes other space hardware manufacturers are pushing the envelope of printed hardware, notably Boeing, Aerojet Rocketdyne and Space Exploration Technologies (SpaceX), all of which are responding in part to defense spending reductions that have opened the door to technological innovation, resulting in new materials and techniques that can reduce production time and lower costs.

To that end, Ambrose says, Lockheed Martin expects to almost halve the length of time necessary to build complex military satellite systems, which take on average up to eight years.

"Our goal is to get that down to under five years," he says. "We think it is doable within three to five years."

In the meantime, one of the biggest challenges companies face is the cost to replace printing hardware, which can become obsolete within a year from purchase. Another obstacle is training engineers to design hardware with additive manufacturing in mind.

"We brought in some engineers that had just graduated from college and said 'Go back to fundamentals, design something that you can't machine,'" Ambrose says, adding that the result was a bracket with an order of magnitude reduction in mass.

"It looks like something you would never design, but it transfers the loads, the thermal energy, and works just fine," he says. "You can't machine it, but you can print it." ☛



LOCKHEED MARTIN

Revamped A2100 space bus offers all-electric, all-chemical, hybrid propulsion, with 3-6 months more "decision space" to choose a launcher.

Spark Plugs

To see where the U.S. defense base is going, some say 'check your driveway'

Michael Bruno Washington

Bill Lynn has seen the future of the U.S. defense industry, and it looks a lot like a Honda Civic.

Lynn—a former No. 2 Pentagon official and now CEO of the North American arm of Italy's Finmeccanica and its U.S. proxy DRS Technologies—recalls how in the late 1970s and early 1980s it was unpatriotic for Americans to drive a car without a Detroit provenance. Everything about cars in the U.S. then was American, from their supply chains to their shareholders, headquarters and customers.

Fast-forward to today and the U.S. car business reflects a world of change. Of the top 10 most "American-made" cars, five have traditionally foreign nameplates, Lynn says, citing trade publication research listing the Toyota Camry and Honda Odyssey. The U.S. car manufacturer with the most exports outside North America now is German-born BMW, thanks to a manufacturing plant in Spartanburg, S.C. And Honda says that as of last year it exported more cars from the U.S. than it imported from Japan.

"This has become a truly global industry," Lynn says. "The nameplate [and] what the shareholder base of the company is in the auto industry has become less important. It's the technology. Jobs remain important, but international companies have international production bases."

"This is the kind of path the defense industry is going to have to go down," Lynn adds.

Increasingly that viewpoint is being shared by others, including consultants at Booz & Co., analysts at the progressive Center for New American Security (CNAS) think tank and, to varying degrees, some current Pentagon officials. Ironically, the U.S. may have to become more global and more commercial in sourcing its defense hardware to maintain its military superiority.

"We need to move faster," Pentagon acquisition chief Frank Kendall told lawmakers in July, "and we also need to access technologies that we're not accessing today."

To be sure, Lynn and Booz have business reasons for disseminating this viewpoint widely. Lynn spoke at a recent Atlantic Council event here and at an April sit-down with Aviation Week (*AW&ST* April 21, p. 52). Booz Aerospace and Defense Vice President Jim Adams and Principal Steve Beckey addressed Aviation Week's Defense Technology and Requirements Conference in March. Moreover, Lynn cites Booz research in his speeches, and he recently cochaired a new CNAS study that draws similar conclusions.

Together they posit that the U.S. defense industrial base, by far the world leader in size and output, is entering its fourth iteration since American colonies declared independence from Britain. Before World War II, industry largely entailed government-controlled arsenals and shipyards that were erected and shuttered as needed. With the war's production demands, other industries were pulled in to help and many retained some of that business to become multi-industrial conglomerates. After the Cold War, consolidation was encouraged and the sector was dominated by defense specialists.

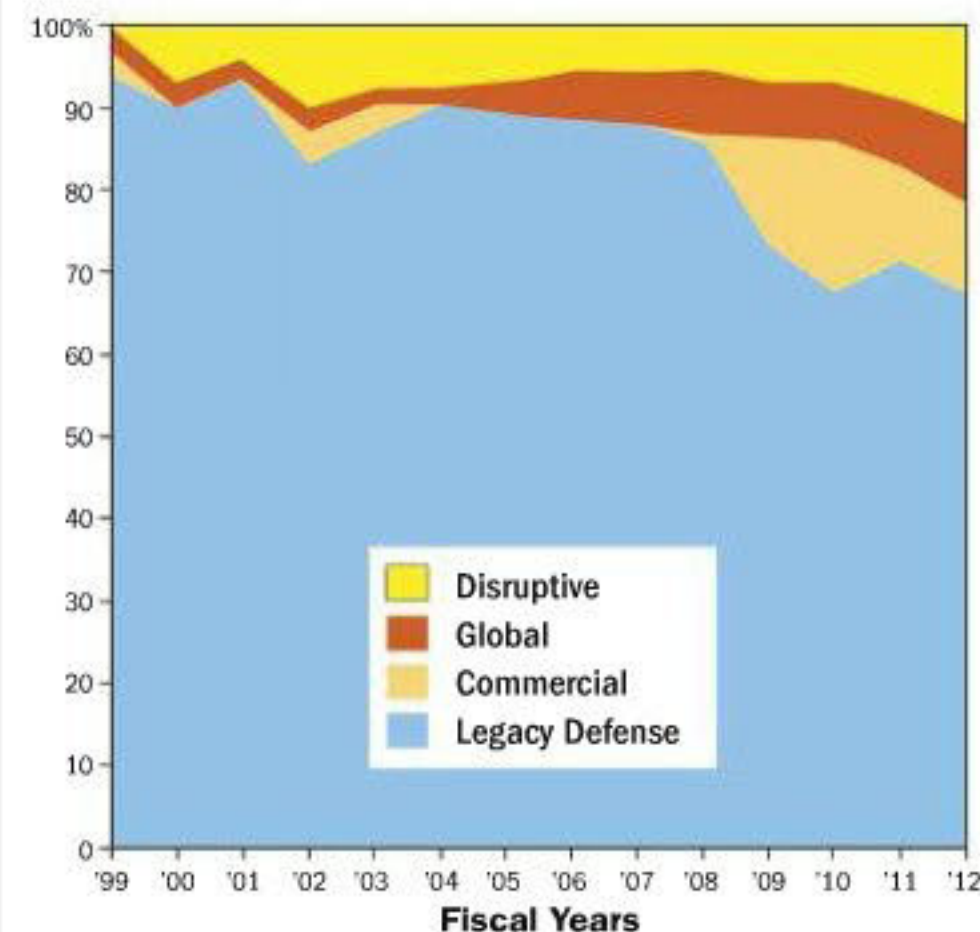
Whether we are in the midst of another paradigm shift remains to be seen, but many observers are eyeing the rise of globalization and commercialization in the aerospace and defense sector. The CNAS report, "Creative Disruption," includes a poll that shows of 1,019 cognoscenti surveyed, about 75% say they believe by 2030 there will be more commercial companies than specialists doing business in the U.S. sector. A similar percentage believes there will be more underlying commercial technology in the realm than vice versa.

The CNAS report states the case in its foreword. "Google's recent acquisition of Boston Dynamics, a Darpa-funded organization that develops some of the world's most innovative robots, served the Pentagon with an unsettling notice: The center of gravity in cutting-edge, military-applicable research is shifting abruptly away from

the defense establishment to relatively new commercial firms with loads of cash to invest," the authors say. "This is just one example of a broader trend in which commercial and international firms are taking the lead in what once was the technological province of the Department of Defense."

Indeed, while the U.S. strategy of relying on superior military technology

Defense Specialists Lose Share in New Platforms . . .



is not changing, the underlying conditions for how officials and executives provide and maintain it are—for better and worse. During the Cold War, A&D companies were seen as the epitome of "leading-edge" research-and-development centers with the likes of Lockheed Martin's Skunk Works, albeit due in part to significant government spending. But analysts and others also criticized industry for not benchmarking results as the rest of Corporate America does, especially pertaining to relatively low levels of "return on investment" for shareholders and investors.

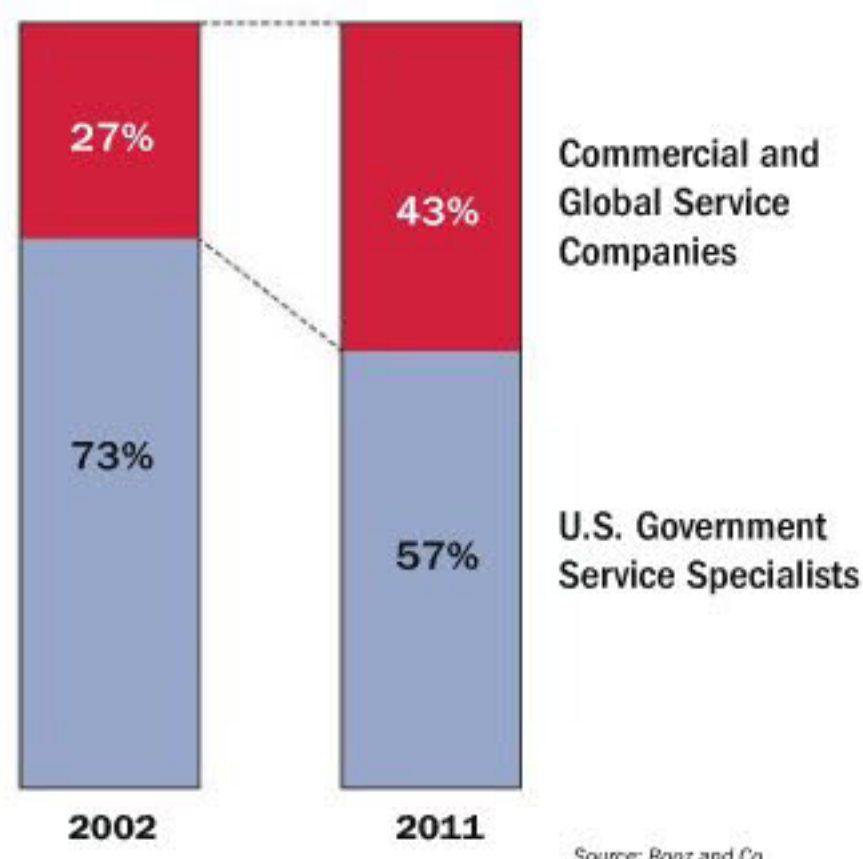
Now, after decades of financial engineering, plant closings or mergers and acquisitions, prime A&D companies are considered more akin to utility companies that are cash-generators for those who own them. Yet one major bill-payer has been so-called independent R&D spending—as in company funded—which has slowed to a trickle (*AW&ST* June 9, p. 46). Government R&D, meanwhile, also has fallen as overseas wars wind down and the U.S. tries to recover from the 2008 financial crisis and accumulating deficits.

"We're not seeing the same level of R&D investment today as we did before, and in particular, relative to the rest of the [U.S.] economy,

it has been shrinking," Lynn says.

"It also starts to make the point that the technologies we need are increasingly coming from outside the defense industry," he continues. "It used to be the case that, on balance, defense was a net exporter of technology," he says, referencing the Internet and GPS. Not so anymore. "3-D printing, nanotechnology, the cloud, autonomous vehicle

... As Service Providers Gain Ground in U.S.



technology—a lot of that is being done outside defense," Lynn notes.

To be sure, observers like Lynn, Booz and CNAS believe defense specialists will remain, just as there are arsenals and shipyards today, even if in hybrid form as shipbuilder Huntington Ingalls is sometimes considered. But they see an inevitable and continuing decay of legacy platform providers' positions, as well as the rise of global and commercial "customizers" who adapt their offerings to government clients (see charts).

"Legacy defense companies have a falling share in a declining market, and shareholders know it," Adams and Beckey say. "Some [will] move up, some move down into commercial, and some stay where they are and get squeezed. They essentially become low-growth utilities until the next upturn happens."

The consultants say more industrial consolidation is inevitable starting with the fact that only around 5% of industrial capacity has been taken out via plant closings, layoffs and restructurings to date in this downturn. "It probably is not going to be enough," Beckey says.

Harking to legendary A&D executive Norm Augustine, who in the mid-1990s quipped that industry's attempts

to go into "adjacent" or related markets were "unblemished by success," the Booz consultants say this is no panacea, either. Defense companies have tried going into adjacent markets, including book publishing, an asphalt plant and carmaking. In every one of those cases—50 examples Booz looked at—"it just didn't work."

Finally, while Washington would have to ease current limitations on primes consolidating, massive changes have taken place already. In 2006 the Pentagon allowed Boeing and Lockheed Martin to form the United Launch Alliance monopoly. Could there be a "United Tactical Aircraft Alliance" or "United Ground Vehicle Alliance" in the future? Maybe, especially as federal outlays catch up to sequestration cuts and legacy providers are forced to cut much more infrastructure to maintain or raise profit margins.

When the next wave of consolidation occurs, Lynn argues, the Pentagon should focus less on trying to maintain competition in platforms like aircraft, shipbuilding and ground vehicles, and more on encouraging competition in robotics, missiles, vehicles, electronics and communications. "Partly because it's just a fact of life," he says, "and partly because that's where the future is."

Others echo the sentiment. "Investors need to consider the potential implications of these shifts, particularly in cloud-related services, unmanned aerial vehicles, autonomous vehicles, satellites and space launchers," says

analyst Byron Callan of Capital Alpha Markets. "This is an important defense theme, although its full implications may not be manifest until 2016-18."

As for surviving legacy players, they should consider the car industry's modular, product-line approach, according to Booz. "We see the automotive companies do this all the time: take the same platform and apply it across multiple different cars and get that reuse, or take a family of engines and apply it to the entire product line of all the cars they are producing," Beckey says.

"If you look at most defense aircraft that come off a production plant, almost no two aircraft are ever the same," he adds. "That is definitely not the way they would run an automotive plant. Even though there is customization allowed, they found a way to allow the customization and keep stability in the system."

The challenge for both officials and executives alike will be managing the transition, but Lynn sees reason for hope. Both right after World War II and the Cold War, officials and executives were able to do some planning and execution of major change without losing the U.S. military's technological and industrial lead over the rest of the world.

"We managed it then," Lynn says. But the threshold remains high. "The test of successful management is that we're able to retain our technological edge, our industrial base edge, even as the sector itself shifts shape and structure." ☛

DEFENSE

Staying Alive

U.K.'s Sentinel in line for possible upgrades

Angus Batey **RAF Waddington and Farnborough**

A British surveillance aircraft system, controversially scheduled for an early retirement in Parliament's 2010 defense review, is getting a new lease on life.

The Royal Air Force's airborne stand-off radar (Astor) system is based around five Sentinel R1 aircraft. The Bombardier Global Express business jets are equipped with a dual-mode ground moving-target indicator (GMTI) and synthetic aperture radar (SAR) by prime contractor Raytheon. The aircraft had been scheduled

for a post-Afghanistan retirement.

However, Sentinel was granted a reprieve, according to a speech given by Prime Minister David Cameron at the Farnborough International Airshow in July. Cameron's announcement had been widely expected following successful deployments to Libya, to Mali and in Operation Pitchpole, a mission supporting the U.K.'s environment agency following severe flooding in southern England this year. One air force Sentinel has deployed in Africa, supporting efforts to find schoolgirls

kidnapped by Boko Haram, while aircraft have been deployed in support of ground forces in Afghanistan since February 2009. The system has become increasingly valuable to the British military and its allies, and as an Army cooperation squadron expands its utility, Raytheon is looking to sell versions of the Sentinel capability to other customers in a variety of configurations and on different platforms.

Aviation Week joined a Sentinel sortie during Exercise Joint Warrior earlier this year. Within an hour of departure from RAF Waddington, in Lincolnshire, the jet was at operational altitude above Scotland on its first orbit. There were three main tasking lines for the day: determine the serviceability of a railway bridge near Carlisle, monitor ground activity at the RAF's Spadeadam electronic-warfare tactics range and at Carlisle Airport, then perform maritime surveillance on the Solway Firth.

"The radar is looking for movements on the ground within the area of the exercise to try and identify to friendly forces where other things are moving," explains Flight Sgt. Mark Fort, one of three crew at computer workstations in the rear of the aircraft. "In the maritime domain, we're practicing protection of friendly vessels. We're giving them warnings of fast-movers around them and approaching them."

To Fort's left, Sgt. Michael Bighi, one of the tri-service squadron's complement of Army personnel, is examining SAR imagery of the bridge at Wetheral. The image is inconclusive, and the crew are at pains to avoid making assumptions: so Bighi asks for the radar to be switched back to GMTI mode, and does not assess the bridge as serviceable until he has watched the string of dots of a train leaving Carlisle station and has made sure it completes a crossing.

Another SAR image of the nearby airport shows what are, even to the untrained eye, three helicopters parked on the apron. Bighi knows from the mission briefing that the helicopters in the area are Sea Kings, Merlins or Lynxes, so by interpreting the image on his screen he identifies the three aircraft as the latter.

Fort—Sensor One on this flight—and Bighi (Sensor Two) report to the third member of the rear crew, the airborne mission controller. This RAF officer is responsible for ensuring the aims of the mission are being met.

"I've got overall control of what's happening down the back of the aircraft," he says. "That means making sure . . . we're in the right place, the radar is turned on, and pointing in the right direction to collect the imagery or MTI data we're after."

The squadron has been trying new things as the system has bedded in. Sentinel's utility in the littoral is not yet a declared capability, but exercises like Joint Warrior are adding to experience gained during deployment over



The Airborne Mission Controller (nearest camera) scans imagery during a Sentinel sortie on Exercise Joint Warrior, over Scotland.

Libya and are helping to fill the U.K.'s maritime-patrol gap. The Pitchpole mission also helped extend operational parameters.

Raytheon has been planning a number of major upgrades for Sentinel, which it, and the squadron, hope will be funded now that the system's future has been secured. Of most urgency are structural checks and airframe life-extension maintenance, which had been delayed pending the decision. An upgrade of mission-crew software is also necessary, but this may now be folded into a larger project to develop and fit completely new workstations and computers.

The current concept for the new mission system is called Overseer, and it is among the items that will dominate discussions between the contractor, the squadron and the defense ministry over where the new money will be spent. The squadron and Raytheon also have a prioritized "shopping

list" of other work to carry out. This includes refinements to the radar and an evaluation of additional sensors.

"We're considering the implementation of a long-range optical sensor, which we can then integrate with the radar and provide a much better surveillance capability," says Paul Francis, Raytheon U.K.'s business development director. "[We are also considering] implementation of a signals-intelligence capability on the platform, to pick up and highlight some of those areas where, just with the radar, it's difficult to form identification."

There is a significant market for surveillance systems based on business-jet platforms. Low cost of ownership, a quick route to fielding technology and a wide operational envelope are key to the appeal, company officials say.

"Two customers are looking for a turreted [electro-optical/infrared] capability to be able to move down quickly from altitude, which the business jet uniquely allows you to do," says Jim Hvizd, vice president of international strategy at Raytheon's space and airborne systems. "We're leveraging technology we developed on Global Hawk, where we have an integrated long-range camera capability."

Long-range optical sensors under consideration include UTC Aerospace Systems' DB-110, currently in the RAF inventory via the Tornado GR4's Raptor pod. UTC has developed two much smaller pods for the sensor. The company is also developing a multispectral sensor to fit the same pod form, pylon and avionics architecture.

"We've been talking, at very low level, about what the equipment would give in terms of missions complementary to the SAR/GMTI. The aircraft being extended seems to be a gateway to opening that up," says Andy Jeffrey, a UTC business development director.

Aviation Week understands that the concept being pursued for Sentinel/DB-110 integration would enable the EO/IR sensor to be cued by the radar; and both would be able to operate at the same time. DB-110 imagery could be analyzed on board and fused on the Overseer workstation displays with the SAR and GMTI data, or viewed on its own, as required.

But Jeffrey does not say how far a combination of the sensors or a multispectral sensor would go toward a multi-mission aircraft capability. "I think that discussion is yet to be had," he says. ☛

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Aug. 25—Ninth Asia-Pacific Congress of Aerospace Medicine. Beijing. www.apfama.org/2014
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Sept. 10-12—International Air Transport Association's 10th Maintenance Cost Conference. Divani Palace Acropolis, Athens. www.iata.org/events/Pages/mcc-2014.aspx
Sept. 16-18—Alaska UAS Interest Group Annual Meeting 2014. Anchorage. See www.uasalaska.org
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Russia Breaching INF. Now What?



Collina is the research director at the Arms Control Association in Washington.

Last week, the Obama administration officially accused Russia of cheating on a landmark arms control pact, the Intermediate-range Nuclear Forces (INF) Treaty, signed in 1987 by U.S. President Ronald Reagan and Soviet leader Mikhail Gorbachev.

A Russian violation of a major arms control treaty is a serious matter that deserves a serious response. But let's not overreact. A "tough" response, such as withdrawing from the treaty and building new weapons, would be premature and counterproductive. Russia's actions pose more of a political challenge to the U.S. and its allies than a military threat.

The administration's specific allegation is that Russia is violating its INF obligations "not to possess, produce, or flight-test a ground-launched cruise missile (GLCM) with a range capability of 500 km to 5,500 km, or to possess or produce launchers of such missiles." This apparently means that Moscow is testing an interme-

Russian activities that are inconsistent with the INF Treaty and eliminate prohibited missiles and launchers in a verifiable way. The U.S. should work with its allies to bring diplomatic and economic pressure to bear on Moscow to achieve these goals.

Unfortunately, this is not the only issue on Moscow's naughty list, which also includes Crimea and eastern Ukraine and Malaysia Airlines Flight 17. But the INF issue is too important to be lost in the shuffle.

It would be foolhardy for the U.S. to withdraw from the INF Treaty, as Sen. Marco Rubio (R-Fla.) and others have suggested, for the simple reason that Washington has no military need to deploy intermediate-range ground-launched ballistic or cruise missiles. If the U.S. fielded such weapons on its territory, it could threaten Canada and Mexico. Fielding these weapons in Europe would be a political non-starter and serve no useful strategic purpose; Washington has thousands of long-range nuclear weapons that can reach Russia on short notice.

Moreover, U.S. withdrawal would give Russia an excuse to do the same, allowing Moscow to openly deploy INF-banned cruise and ballistic missiles.

In July, Stephen Rademaker, a former Bush administration arms control official, told the House Armed Services Committee, "I do not believe the appropriate remedy in this case is for the United States to withdraw from the treaty. Rather, since Russia so clearly wants out, we should make sure that they alone pay the political and diplomatic price of terminating the treaty."

The best outcome would be for the U.S. and Russia to engage in further discussions to promptly resolve Moscow's violations. U.S. officials said President Barack Obama sent a letter to Russian President Vladimir Putin seeking a "high-level dialogue" aimed at preserving the treaty.

This is the same approach Reagan used in 1983, when Russia was violating the Anti-Ballistic Missile Treaty. Rather than withdraw, Reagan pressed Moscow to come back into compliance. Reagan's approach worked, and led to additional agreements like INF and the 1991 Strategic Arms Reduction Treaty (Start), which significantly reduced the nuclear threat to the U.S.

Yes, arms control can be a messy process, but it gets results. Existing U.S.-Russian arms control agreements, such as INF and the 2010 New Start, still serve as anchors of stability and predictability—but Russia must comply with its commitments. The U.S. can help by building international pressure on Moscow to stay in the fold, and by resisting any temptation to withdraw from INF. U.S. withdrawal would be a gift to Moscow, not a punishment. ☛

“U.S. withdrawal would give Russia an excuse to do the same, allowing Moscow to openly deploy banned cruise and ballistic missiles.”

mediate-range cruise missile from an operational ground launcher, which is not allowed, as opposed to testing from a test launcher, which is allowed.

Russia denies the charge, which so far is not hard to do. According to *The New York Times*, U.S. officials do not believe Moscow has deployed the prohibited missile. Any evidence of deployment would make the Kremlin's denial much less credible.

For now, the U.S.'s primary goal should be to bring Russia back into full compliance with the INF. Why? Because Russia apparently wants to build mid-range cruise missiles that are prohibited by the treaty. If deployed, these weapons could threaten U.S. allies (but not the U.S. directly). Make no mistake, this treaty is not some dusty artifact—it has served U.S. national security interests for over 25 years, and still does.

INF marked the first time the superpowers agreed to reduce their nuclear arsenals and use extensive on-site inspections for verification. The treaty eliminated almost 2,700 missiles, most of them Russia's.

U.S. policy should be to seek an immediate halt to all

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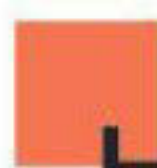




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