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With Lockheed's CEO

**ELECTRIC PROPULSION**  
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**Boeing's Plan to Keep  
The 747-8 Alive**

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**MRO Edition**

STARTS AFTER PAGE 26

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# AVIATION WEEK

## & SPACE TECHNOLOGY



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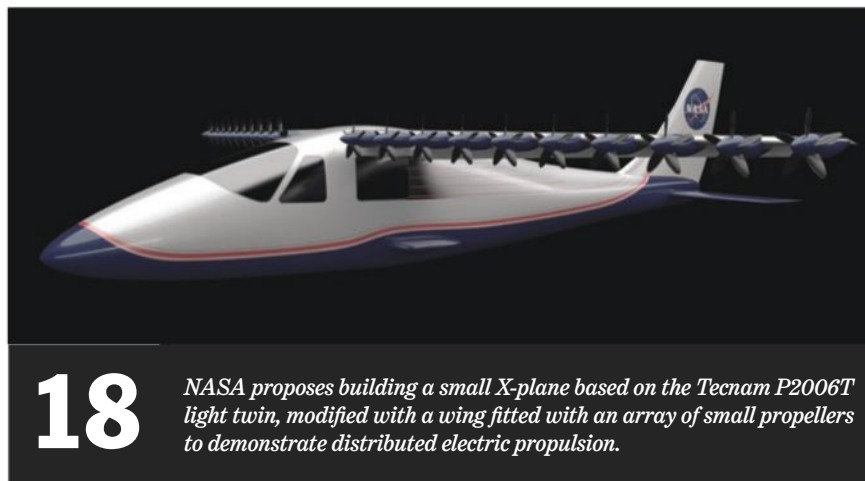
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### ON THE COVERS

This week, Aviation Week publishes two editions. The far left cover photo from Dassault features one of the company's Rafale fighters in a heavyweight configuration that was tested this year. It carries six air-to-air missiles, six Sagem A2SM guided bombs and three 2,000-liter fuel tanks. A special report on European fighter upgrades begins on page 32. Elsewhere in both editions are an interview with Lockheed Martin CEO Marillyn Hewson (page 28) and reports on electric aviation (page 18) and the next steps for the Boeing 747-8 (page 21). Our MRO Edition includes a report on parts-buying essentials—from demand forecasting to parts logistics and distribution. Its cover photo from AJW Aviation shows the firm's state-of-the-art warehouse and logistics complex near London Gatwick Airport.

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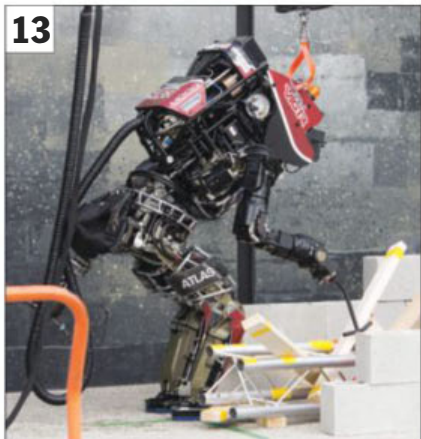
Ei Tokuda, VP Maintenance & Flight Operations Support Department, Customer Support Division, Mitsubishi Aircraft Corporation

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### A round-up of what you're reading on AviationWeek.com

Aviation Week editors will be on the ground **at the Farnborough air show** to bring you highlights and insight—and news, photos, videos and blogs. Keep up with the latest and **download our free app** at [AviationWeek.com/Farnborough](http://AviationWeek.com/Farnborough)



TONY OSBORNE/AV&amp;S

Qatar is planning to acquire more fighters, and that could affect the fate of its Mirage 2000s. Tony Osborne got a rare look at the jets when he attended Anatolian Eagle out of Konya Airbase in Turkey. [ow.ly/yHQG8](http://ow.ly/yHQG8) **AviationWeek.com/Ares**

## F-35 UPDATE

Our editors discuss some of the current issues surrounding **the Joint Strike Fighter**, including its role **in international fleets**, in the Check 6 podcast this week. Check 6 is also available for subscription on iTunes. [AviationWeek.com/podcast](http://AviationWeek.com/podcast)

### READER COMMENT

Speaking of the JSF, the question of whether the F-35B, the Stovl variant the U.K. is buying, **will be ready to go England in time for the Farnborough air show** provoked a lively online discussion. RSM wrote: "I worked on the B-58 from 1953 until 1955. It began flying about 1956. By the time it had flown about as much as the F-35B has flown, about 10 aircraft had become smoking ruins killing most of the aircrews. Be glad that with current simulation and **thorough and cautious testing** there has been no loss of life or airframes of these marvelous aircraft." [ow.ly/yHR8J](http://ow.ly/yHR8J)



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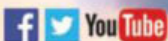


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## VIALE, COOL CARRIER MATS?

As I read Bill Sweetman's recent commentary "Hot Air" (AW&ST May 26-June 2, p. 15), regarding the landing mat challenges for the F-35B vertical-landing aircraft, I wondered if a low-cost, low-tech solution to this problem is already on hand.

Why not investigate the use of a mat that has tubes filled with water?

Tubes would spray water on the surface so that the whole of it is drenched when in use; the water would boil off where heat is applied. This water-cooled mat could be made of ordinary steel, rather than high-temperature stainless, nickel alloy or titanium. If designed well, it would be far less expensive than an uncooled mat made of high-temperature materials.

Dale Gibby

COLUMBUS, INDIANA

## TIRES AS FOILS

It is fascinating to me how many organizations, contracts, people, studies, tests and reports (to say nothing of various journalists) have climbed on the bandwagon of "What will the F-35B exhaust do to a ship's deck during a vertical landing?"

Perhaps nobody in charge of paying for all this has noticed that the rubber tires on the wheels can handle such landings just fine.

John Farley

CHICHESTER, ENGLAND

## SOLAR POWER SOLUTIONS

The three-article coverage of Space Solar Power (AW&ST June 9, pp. 42-45) highlights a bigger problem than just solving future electrical needs. Frank Morring, Jr., wrote about the potential to destroy severe hurricanes, fight global warming by eliminating greenhouse gases, and save lives in combat zones.

But sadly, he also points out that our latest efforts seem only to support man's vainglorious desire to be added to lists that honor the first or fastest in space and flight. China's lopsided funding toward manned flight is mentioned. And readers are undoubtedly aware of the burgeoning private interest toward space tourism and populating Mars.

But consider the glory and the good that could come from being short-listed with an even more elite group—comprising Benjamin Franklin and Thomas Edison, to name but two—who have found solutions to power needs. Who-

ever solves our looming power shortage crisis will be in good company indeed. Dedicate more research to solving problems here on Earth.

Roy Steele

GEORGETOWN, TEXAS



## NEW SOLUTIONS, OLD PROBLEMS

I was reading "Managing Unmanned" (AW&ST June 16, p. 26) when I made the connection between the article contents and a problem that dates back to Future Combat Systems—managing airspace within a battle area. We wrestled with controlling access to all classes of air vehicles, using a rather burdensome, hand-operated system. It took 24 hr. to formulate the air tasking orders for the next 24 hr. What Graham Warwick described is a logical answer to that problem. It could be characterized as "beating plowshares into swords."

The basic communication system could be as simple as the existing cellphone networks for low-flying unmanned aerial systems. I can see that the computing architecture could be similar to that used by the cell providers. There are few times when a new idea really seems logical and practical—this is one of those times.

Thomas L. Parker

HUNTSVILLE, ALABAMA

## SUPERCOMPUTING POTENTIAL

In "Computing Crunch" (AW&ST May 19, p. 18), Graham Warwick points out that even with efficiency improvements, an exascale (1E18 flops) supercomputer is projected to require 20-200 mega-

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watts or more. These numbers match power-generation figures for small modular reactors. Since a key factor is utilization, processing at or near capacity for extended periods, this operating load could be considered ideal for a dedicated nuclear power application.

I am a nuclear engineer, and at the lab where I work we had proposed to model such a system using a small modular reactor coupled to a supercritical fluid Brayton-cycle power converter and a power buffering capacitor bank (or equivalent). Unfortunately, it wasn't funded, but the concept is interesting and should be food for thought for future study.

Rodney L. Keith

ALBUQUERQUE, NEW MEXICO

## DUAL-REGISTRATION NO. SUSPECTED

Something does not add up with reader Bill Johnson's letter and accompanying photograph (AW&ST June 16, p. 9) about his memory of Lufthansa Boeing 747 training in 1971 and the photo of D-ABYC.

The photo is of a Boeing 747-8, which was manufactured in 2012 so could not have been the aircraft Johnson saw in 1971. I am curious as to whether Lufthansa reused the registration D-ABYC on two different aircraft. Can anyone shed light on this?

Finbar Constant

CORK, IRELAND

## A350, FOR SURE

Surely the caption accompanying a photograph in "New World" (AW&ST June 30, p. 53) should indicate that the aircraft is an Airbus A350, not the A340, as stated.

Alan Green

ZURICH, SWITZERLAND

(The reader is correct—Ed.)



# Who's Where

**John Rood** has become vice president-domestic business development for the *Lockheed Martin Corp.*, Bethesda, Maryland. He succeeds **John Ward**, who plans to retire Aug. 1. Rood was vice president-U.S. business development for Raytheon. **Steve O'Bryan** has been named vice president-international strategy and business development. He follows **Rick Kirkland**, who is now vice president-international strategic initiatives. Kirkland was responsible for all Lockheed Martin business in India, Australia and Singapore. **Jack Crisler** has been appointed vice president for F-35 business development and strategic integration, succeeding O'Bryan. Crisler was vice president-business development for air mobility, special operations and maritime programs for Lockheed Martin Aeronautics.

**Wayne Prender** (see photo) has been named vice president of the Ground Control Technologies organization of *Textron Systems' Unmanned Systems*, Hunt Valley, Maryland. He was program director within the small/medium-endurance unmanned aircraft systems group.

**Bill Toti** has been appointed president of San Diego-based *Cubic's* Mission Support Services segment. Toti also will be a senior vice president of the Cubic Corp. He was vice president/account executive for the U.S. Navy and Marine Corps Accounts for Hewlett-Packard Enterprise Services. Toti will succeed **Jimmie Balentine**, who is retiring but will remain as the segment's chairman.

**Cyriel Kronenburg** has become vice president-sales and marketing for *Aireon*, McLean, Virginia. He was global head of air traffic control matters for the International Air Transport Association and had been its head of government and infrastructure affairs for North America and the Caribbean.

**Paul Witt** has been appointed executive vice president-operations of *Stevens Aviation*, Greenville, South Carolina.

**Leanne Collazzo** (see photo) has been named vice president-commercial aviation for Fort Worth-based *Elbit Systems of America*.

**John Clements** has become director

of research, development and testing for *Proof Research*, Columbia Falls, Montana. He was weapons program manager at the Naval Special Warfare Development Group.

**Jeff Plant** has been appointed leader of the *American Airlines* team at Dallas/Fort Worth International Airport. He was the airline's managing director at Los Angeles International Airport. Plant succeeds **Art Pappas**, who will be retiring.

**Glenn Hausmann** (see photo) has been promoted to manager of *FlightSafety International's* Learning Center at New York LaGuardia Airport from the facility's director of standards and manager. He succeeds **Ralph Lintelman** (see photo) who has been named manager of the Learning Center in Wilmington, Delaware. Lintelman follows **Barry Massey**, who plans to retire on July 31.

**Col. Larry Myrick** of San Luis Obispo, California, has been named the next national vice commander of the *Civil Air Patrol*. He is an adviser to the CAP national commander, Maj. Gen. **Chuck Carr**. Col. **Larry Ragland**, who has been Middle East commander, has been named chief of staff to the national commander, Brig. Gen. **Joe Vazquez**. U.S. Army Lt. Col. **Jayson Altieri** of CAP's North Carolina Wing, has been appointed vice chairman of the CAP board of governors. He succeeds Lt. Col. **Ned Lee**, whose board term ended May 2.

**Candace Chesser** (see photo) has been promoted to program manager from deputy program manager of the *U.S. Navy's Air Combat Electronics Program Office*, NAS Patuxent River, Maryland. She succeeds Capt. **Tracy Barkhimer**, who has retired.

Chesser was principal deputy program manager for the Naval Air Traffic Management Systems Program Office.

**Kevin A. Bell** (see photo) has been appointed lead executive for *Northrop Grumman Corp.* business in Dayton,



Wayne Prender



Leanne Collazzo



Glenn Hausmann



Ralph Lintelman



Candace Chesser



Kevin A. Bell



Larry Hungerford

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Ohio. He retired from the U.S. Air Force as assistant to the commander of the Aeronautical Systems Center at nearby Wright Patterson AFB.

**USN Rear Adms. (lower half) Mark W. Darrah, Mathias W. Winter and Gordon D. Peters** have been selected for promotion to rear admiral. Darrah will become program executive officer for Strike Weapons and Unmanned Aviation at Patuxent River, Maryland. He will succeed Winter, who has been named chief of naval research/director of innovation, technology requirements, and test and evaluation. Darrah has been commander of the Naval Air Warfare Center's Aircraft Div./assistant commander for research and engineering at Naval Air Systems Command, also at Patuxent River. Peters will follow Darrah and has been program manager for the presidential helicopters program, also at Patuxent River. Capt. **James W. Kilby** has been selected for promotion to rear admiral (lower half) and assignment as commander of the Navy Surface Warfare Development Command at San Diego. He has been deputy for ballistic missile defense for Aegis, destroyers and future surface combatants in the Office of the Chief of Naval Operations at the Pentagon.

**Larry Hungerford** (see photo) has been named president/CEO of Washington-based *Terma North America Inc.* He has been its vice president-business development for command, control and sensor systems, and was vice president-domestic business development for space programs at Lockheed Martin. ☉

## DEFENSE

### Four Bs or Not Four Bs

Four F-35Bs are due at RAF Fairford in England to allow pilots time for verification flights in advance of their debut flying displays at the Royal International Tattoo this week followed by the Farnborough air show next week. As of July 2, the single-leg transatlantic crossing of the foursome was on hold, as the single British F-35B slated for the show remained on the ground at Eglin AFB, Florida. The other three F-35Bs, operated by the U.S. Marine Corps, had arrived at NAS Patuxent River, Maryland, the departure point for their historic Atlantic crossing. Investigators continue to explore the cause of a fire that broke out June 23 on an F-35A preparing for takeoff of Eglin; Air Force F-35As and Navy F-35Cs continue to be on a "safety hold" from flight ordered by local commanders. Marine operations were temporarily allowed for the three Bs slated for the U.K. to transit from Yuma, Ariz., on June 27. Program officials continue to say this is not a full grounding of the fighter.

### Russian Su-25s to Iraq

The Iraqi defense ministry has taken delivery of 10-12 Sukhoi Su-25 ground-attack aircraft from Russia. The Su-25s are expected to become operational soon, but late last week, it was not clear exactly how many had been received or who will fly them. It is unlikely that Iraqi pilots will have had enough time to adapt to the type, although the Iraqi air force previously flew the model during Saddam Hussein's rule. It is possible the aircraft could be flown by pilots from neighboring Iran, which has a number of former

### Pogue Award Honors Top FAA Administrator

Margaret "Peggy" Gilligan, the associate FAA administrator for aviation safety, has won the 2014 L. Welch Pogue Award for having had a dramatic impact on aviation safety during her career. One of the main reasons for the selection of Gilligan is the shift to sharing real-time operational data to unlock safety-related trends that otherwise would have remained hidden. Aviation Week and the International Aviation Club of Washington bestowed the Pogue Award at a



NASA/BILL INGALLS

of atmospheric chemistry and air quality, as well as moisture, aerosol and cloud patterns.

The 1,000-lb. OCO-2 replaces NASA's first Orbiting Carbon Observatory, which was launched Feb. 24, 2009, but failed to reach orbit. The loss was traced to the failure of the payload fairing on the Orbital Sciences Taurus XL launch vehicle.

## NASA Launches Orbiting Carbon Observatory-2

NASA's Orbiting Carbon Observatory-2 cleared initial power and communications checkouts following a nominal liftoff aboard a United Launch Alliance Delta II rocket from a foggy Vandenberg AFB, California, early July 2.

On its way to a 438-mi.-high, Sun-synchronous orbit, the satellite began a two-year, \$468 million primary mission to assess carbon dioxide (CO<sub>2</sub>) levels in the Earth's atmosphere and the influence of greenhouse gases on climate change.

The so-called OCO-2 is NASA's first mission dedicated to studies of atmospheric CO<sub>2</sub> processes. Within a month, OCO-2 is scheduled to be maneuvered to the lead position in the A-train constellation, a loose formation of international multimission spacecraft configured for near-simultaneous Earth observations

Iraqi air force Su-25s still in operational service, after they were flown from Iraq during the first Persian Gulf war.

### U.S. Navy Aircraft Awards

The U.S. Navy awarded about \$5.6 billion in aviation transactions at the end of June. Northrop Grumman Aerospace Systems received a \$3.6 billion modification to change the advanced acquisition contract for E-2D Advanced Hawkeyes to a multiyear, fixed-price-incentive-firm target contract. The contract modification further provides for procurement of 25 full-rate-production E-2Ds. Work is expected to be completed in August 2021. Meantime, Boeing received a \$1.94 billion fixed-price-incentive-fee contract for full-rate production of 11 Lot 38 F/A-18E Super Hornets and 33 EA-18G Growlers. The Navy is slated to receive 21 of the Growlers and Australia

12. Work under this contract—under which Northrop also benefits as a major subprime provider—should be completed in December 2016.

### Cloud Stealth

The U.S. Navy last month tested how radar-absorbing, carbon-fiber clouds can prevent a missile from detecting and striking its maritime target, Navy officials say. The Navy tested the manmade clouds, called maritime obscurant generator prototypes, to assess their tactical effectiveness for anti-ship missile defenses. The systems and tactics were tested off Guam under a variety of at-sea conditions using unidentified assets from the Army, Navy and Air Force to evaluate how the radar-absorbing, carbon-fiber clouds can protect naval assets as part of a layered defense, officials say. "Pandarra Fog is an example of the quick-turn integrated technical and tactical development the fleet is doing to master electromagnetic maneuver warfare and assure access of joint forces," says the U.S. 7th Fleet commander, Adm. Robert Thomas, Jr. "Our initial assessment is the testing was very successful in terms of tactical employment, usability and cost-effectiveness," says Capt. David Adams, who leads the fleet's Warfighting Initiatives Group.



GETTY IMAGES FILE PHOTO

dinner June 26. Gilligan is the second woman to receive the award since it was first given to L. Welch Pogue in 1994. Pogue was the chairman of the Civil Aeronautics Board appointed by President Franklin D. Roosevelt, and he represented the U.S. at the 1944 Chicago Convention that laid the regulatory foundation for international commercial air transport.

## SPACE

### Mars Request

Mars One, the Dutch nonprofit with

## First Flight for Production HondaJet

The first production HondaJet has taken to the skies, bringing the aircraft closer to certification as planned in early 2015.

The aircraft reached 15,500 ft. and 348 KTAS on June 27 on an 84-min. flight from the company's headquarters at Piedmont Triad International Airport in Greensboro, North Carolina. Test pilot Warren Gould was pilot-in-command. The flight was used to evaluate low- and high-speed handling characteristics, avionics and system functionality.

Flight of the first production model follows a development program that has spanned more than a decade and a least six proof-of-concept and conforming models. Honda Aircraft secured type inspection authorization (TIA) late last year, following certification of the aircraft's GE Honda HF120 engines. TIA cleared the aircraft to begin certification flight tests.

Honda is maintaining a steady pace of production—with nearly 10 aircraft on the line—to prepare for delivery immediately after FAA certification. Once certified, Honda plans to build 50 aircraft in the



HONDAJET

first year and then 90 per year as the company works through backlog. Ultimately, the company is targeting 80 aircraft for a “steady-state” of production, says Honda Aircraft President and CEO Michimasa Fujino. While the company has not updated backlog figures, Fujino has said that it will take more than two years to work through the orderbook.

The HondaJet, which will be certified for single-pilot operation, is designed to fly at a maximum speed of 420 kt. and reach 43,000 ft. The aircraft has a 1,180-nm range and will be configured for five passengers.

ambitious plans to start a human colony on the red planet in the mid-2020s, has issued a request for proposals (RFP) for a range of engineering payloads suitable for the robotic lander it hopes to dispatch in August 2018. The lander and its landing area are intended to serve as the staging site for the organization's first settlers. The 17-page RFP seeks responses from the private sector, academia and nonprofits prepared to compete for 44 kg (97 lb.) of total lander payload availability. “We are opening our doors to the scientific community in order to source the best

ideas from around the world,” Arno Wielders, Mars One chief technical officer, said in a statement accompanying the RFP. “The ideas that are adopted will not only be used on the lander in 2018, but will quite possibly provide the foundation for the first human colony on Mars.” On May 5, Mars One announced it had narrowed to 705 people a worldwide applicant list of potential settlers exceeding 203,000 just eight months earlier. The nonprofit subsequently moved to the interview phase of its selection process for the initial four-member crew and subsequent early settlers.

## NASA Facing Cleanup Bill

NASA faces \$1.1 billion in environmental cleanup liabilities from decades of rocket testing and other research activities, according to the agency's inspector general. But NASA's entire budget for such work could be overwhelmed by a single project: restoration of the Santa Susana Field Laboratory northwest of Los Angeles. Working with California officials, NASA has committed \$200 million in 2016-17 to the cleanup of the former rocket-testing facility shared with the U.S. Air Force, which is more than the agency's entire environmental management budget of \$153 million.

## OBITUARY:

It is quite a telling experience to try and search for information about Rollin King on Southwest Airlines' website. In the “Officers” category of the company's official online history presentation, King is only mentioned once: “Rollin W. King, a founder and former president of Southwest Airlines, has been named Vice Chairman and Chief Executive of Panama Air International” (Nov. 26, 1991).

The rise of Southwest to become one of the largest U.S. airlines and, more important, the early role model for low-cost carriers globally has been surrounded by many myths. Probably the most prominent tale centers on a paper napkin, on which King allegedly drew the airline's initial route map between Dallas, Houston and San Antonio in a bar in 1967. Another one is Herb Kelleher's reaction: “Rollin, you are crazy. Let's do it.” Kelleher, later the chairman and CEO, was King's lawyer at the time.

But according to King, that's not quite how it happened. “Never did it,” he said in a 2007 interview 40 years after that famous bar visit, referring to the napkin drawing. “But it was a hell of a story.” And if King is right, Kelleher was trying to talk him out of the idea of setting up an airline in Texas initially rather than jumping at it right away.

The Southwest founder, who remained its largest shareholder for many years, admitted much later that he thought his role was underappreciated. “It has bothered me, but there is nothing I can do about it so I have tried to stop worrying about it. But, you know, only the old people at Southwest know I even existed.”

King came to Texas in 1962 with a Harvard M.B.A. and initially was an investment consultant. Two years later he bought a small air charter company. But Pacific Southwest Airlines (PSA) in California inspired him to try in Texas what would later be known as a low-cost airline. Four years after the meeting with Kelleher and many legal battles later, Southwest started flying in 1971. The airline was initially run by Lamar Muse, while King stayed in management, but Muse (and a few others) and King did not get along. He flew as a Southwest pilot until 1978. King was a member of the board of directors until 2006. But the strained relationship with his former colleagues persisted.

Nevertheless, Southwest is now praising its founder. “His idea to create a low-cost, low-fare, better-service quality airline in Texas subsequently proved to be an empirical role model for not only the U.S. as a whole but, ultimately, for all the world's inhabitants,” Kelleher wrote. Rollin King died June 27 in Dallas from complications following a stroke. He was 83.



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## COMMENTARY

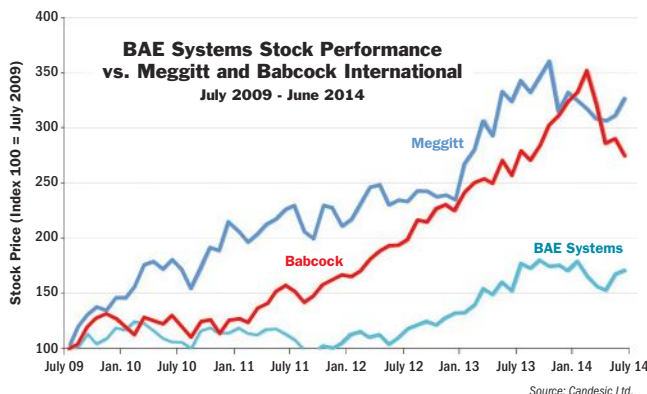
# Out of Steam

## How a 'star of the show' turned into a lackluster performer

**F**arnborough is BAE Systems' home turf, and the air show, which takes place there next week, has traditionally provided the perfect stage for the company to show off its products, political clout, commercial successes and strategic initiatives. Indeed, over the last 15 years, BAE has been the frontrunner of the aerospace and defense (A&D) industry when it came to making bold strategic decisions: the merger with Marconi in 1999, investing massively in the U.S. between 2000 and 2007, creating a defense electronics joint venture with Finmeccanica in 2003, exiting the commercial aerospace business in 2006 and attempting to merge with EADS in 2012.

Yet the overall feeling surrounding BAE today is one of a company that has run out of steam and is critically short of strategic options. In fact, several of its decisions seem to have backfired. They include the 2006 sale of its stake in Airbus (a business for which it was eager to pay a premium to reenter by 2012), the divestment of its share of Saab in 2010-11 (Saab's market cap has doubled since then), and its multiple acquisitions in land systems, which is now one of the most distressed sectors in the defense industry.

This dire strategic position is even more striking when compared with other U.K. A&D players such as Meggitt and Babcock International, which have been riding high in similarly difficult market conditions (see graph). One might therefore wonder if all the strategic moves made by BAE were as smart as they were bold. Indeed, a very rough analysis shows that between 2000 and 2014, the company's



revenues have increased by almost exactly as much as the total of its acquisitions (net of disposals)—that is around £6 billion (\$10.3 billion). This tends to suggest the value created from all these acquisitions has been limited. The company has “captured” a lot of value, but has it actually “created” value?

In this regard, I will limit myself to two comments. First, value creation usually occurs when one fulfills a customer's untapped need.

This process typically requires a company to significantly transform its underlying capabilities and the way it interacts with its clients. For example, the story of VT Group between 1996 and 2008 (before its breakup), moving

away from its historical shipbuilding business and becoming a leader in outsourced government services, illustrates a true value-creation strategy. As far as BAE is concerned, there has been no such story. While there were high hopes that the British Defense Industrial Strategy of the mid-2000s would trigger a breakthrough value-creation process for both the Ministry of Defense and BAE, its implementation did not live up to its promise.

Second, creating value is not just a matter of becoming bigger. Of course, economies of scale are important in a highly capital-intensive industry but by definition economies of scale happen when a single product is manufactured in great quantities. It does not work when multiple products are made in relatively small quantities. That is, by and large, what BAE has been doing. Its top-line growth does not seem to have translated into value creation, as the economics of the business have remained essentially unchanged.

So what are the options for BAE? Like any other business, it must choose between two strategic postures: ride an existing wave or create its own. So far, BAE's strategy has consisted of riding successive waves. It rode the Airbus wave until the winds started to shift, then it moved on to the “U.S. defense bonanza” and became a “pure play” U.S.-centric defense player, then it jumped onto the security wave, rebranding itself as a “defense and security” company for awhile. The proposed 2012 merger with EADS was an attempt at remounting the commercial aerospace wave. Today, there is no obvious wave to catch and the company is at loose ends. Therefore, the only way forward is for BAE to create its own waves.

Indeed, it is possible that in its current configuration BAE has reached the end of its journey, and that the only way to create value is to reshuffle its business portfolio, possibly breaking up the company in the process. In doing so, it could rediscover the front-runner status that made it famous in the first place, and plant the seeds for a new “star of the show” to emerge at Farnborough.

Until then, we will have to make do with a lackluster performer. ☹



## COMMENTARY

# Fly, Robot

## Performing complex human tasks in stressful human environments is key to Darpa robotics

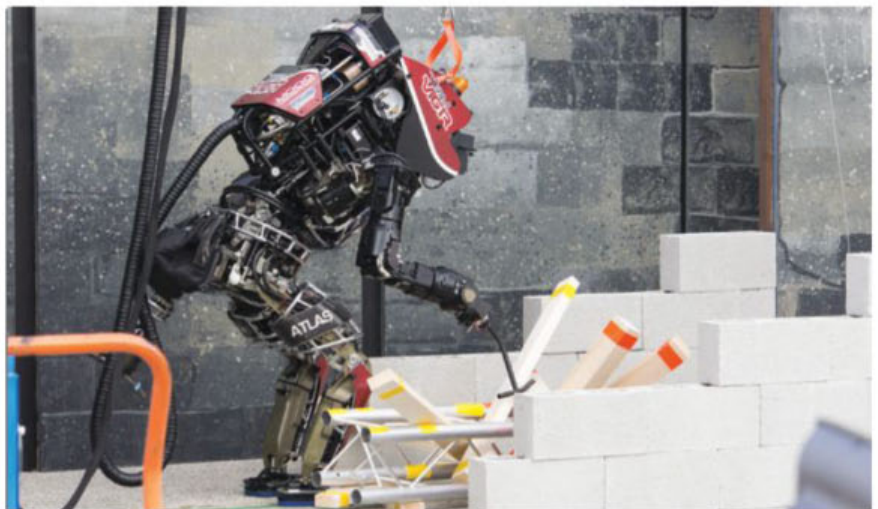
**W**ith its charter to look far into the future, the U.S. Defense Advanced Research Projects Agency is not used to feeling the commercial world nipping at its heels. But the rate of progress in commercial robots is such that the bar is being raised for the Darpa Robotics Challenge (DRC) to propel human-robot collaboration in hazardous disaster zones to new levels.

Does this rapid advance mean robots could enter the cockpit? Another Darpa program suggests it is at least a possibility—although likely not in the shape of a copilot that resembles Iron Man or the Terminator.

The Automated Labor In-cockpit Automation System (Alias) program does not call for a humanoid robot, but like the Robotics Challenge, it requires a solution that can work in environments engineered for humans. In the DRC, robots must be able to drive a vehicle, open doors and use tools designed for humans. Alias must automate cockpit functions performed by humans, in existing aircraft—and do so in a way that is portable, can be installed or removed within a day with minimal impact on airworthiness, and be adapted to another aircraft type in under a month. Each element involves supervision by human operators, but requires autonomy to handle latency and dropouts in communications.

Robots fared better than expected in the DRC trials last December; the winner completed all eight disaster-response tasks, so the agency is allowing teams more time and resources to prepare for the finals, which have been delayed to June 2015. The prize remains \$2 million.

With the progress in robotics, Darpa is focusing the finals on problems unique to disaster response, where harsh environments will require robots to operate without human physical intervention. They will no longer be connected to power cords, fall arres-



DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

sors and communications tethers (see photo), but have onboard power and wireless communications, albeit severely degraded. If a robot falls, it must get up unaided. Limited comms bandwidth and extended dropouts require higher levels of autonomy.

But the agency is letting teams take advantage of advances in cloud and crowd-augmented robotics, where systems can exploit information and computing capacity available in the cloud. On-site operators will be provided high-bandwidth links and be allowed to use as much computing power and as many outside experts as they want, but with severely limited communications to the robots themselves.

Eight tasks performed separately in the trials—from driving a vehicle to opening a door to connecting a hose—will have to be performed sequentially in under an hour. One of the tasks will

be announced on site. The robots are expected to accomplish all eight tasks four times faster than in the trials, says program manager Gill Pratt.

Alias, meanwhile, aims to demonstrate an automation kit that can be installed to enable an existing aircraft to execute a complete mission autonomously from takeoff to landing, including handling failures, with only high-level intervention from a mission commander, on- or offboard, using a single display screen and voice control for primary flight operations.

In a “seedling” demonstration, a Beechcraft King Air fixed-based simulator was modified with stereo vision to

monitor instruments as well as a micro arm to manipulate controls, to enable the operator to interact with the aircraft via a single screen and voice control. The automation system then flew the King Air through simulated missions that involved maneuvering to avoid collision, engine failure, cabin depressurization, autopilot failure and loss of an aileron.

Darpa’s objective is to demonstrate that Alias can reduce the crew in existing aircraft from two pilots to one plus an onboard automation assistant, with a ground operator having the same interface. But as trust in autonomy evolves, the agency believes Alias could lead to completely unmanned ops managed from the ground, or to airborne or ground operators managing formations of automated aircraft. Alias may prove to be more Otto the Autopilot than Robbie the Robot, but it will be a key step toward automated cockpits. ☺



**By Pierre Sparaco**

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

## COMMENTARY

# Europe's Space Launcher

## Ariane's Big Bang

In the coming months, Europe's space community will have to admit it must prepare to pay a high price for a major strategic error. For decades, European Space Agency (ESA)-member states and industrial contractors maintained an outdated structure to develop, produce and market the heavy-lift Ariane booster. Europe acquired a largely dominant market share, despite the former USSR's ambitions. Then came SpaceX, a brand-new player, which is simply revolutionizing the commercial space launch scene.

In June, it became obvious that Europe has made a major collective error, underestimating SpaceX's capability to successfully market commercial launches at a fraction of Ariane's costs. Today everyone is trying hard to maximize the impact of an Airbus Group-Safran initiative to form a joint venture and take control of the Ariane program. Jointly, the two groups own two-thirds of the heavy-lift booster and this is most probably just the beginning of a far-reaching consolidation strategy. Today French space agency CNES retains a 34.6% stake in Arianespace, the launcher's multinational prime contractor, but logically should abandon that role, established by Europe's space pioneers in the 1970s.

In other words, Ariane, despite an excellent reliability record, suddenly appears too complex and far too expensive. Unless it reacts quickly, the company could be seriously endangered by its new California-based competitor. Arianespace long enjoyed secure revenues, was driven by talented engineers



**Ariane's partners are expected to invest €3.2 billion (\$4.2 billion) in a next-generation heavy-lift booster.**

and implicitly took its supremacy for granted. Now comes the wake-up call, exacerbated by the Airbus Group's and Safran's joint decision to respond to the new threat. Doing his best to put on a good show, Arianespace Chairman/CEO Stephane Israel says the planned joint venture is "a major milestone for the European [space] launcher industry." He acknowledges the need to boost the Ariane program's competitiveness and, to achieve such a priority goal, to simplify an outdated industrial structure. This was long overdue.

In June, Genevieve Fioraso, the French minister in charge of space, candidly admitted the looming U.S. competition had been underestimated. And according to Gerard Brachet, a former head of CNES, the consolidation initia-

tive is good news. Such an industrial restructuring should have taken place a long time ago to overhaul a fragmented production arrangement. Ariane subassemblies are manufactured at 20 industrial sites around Europe.

When the Ariane 1 program was launched, succeeding the European Launcher Development Organization's ill-fated Europa II, CNES was selected by participating countries as the program's prime contractor, with France the biggest funding contributor. CNES is a national space agency—not an industrial concern—and it delegated its role to a newly formed company, Arianespace, establishing a complex cross-border work-sharing agreement tied to each participating country's financial contribution. Eventually, it worked, but today it is endangered by SpaceX, a dwarf with fewer than 4,000 people, a fraction of the European giant's massive payroll. And this is why Ariane 5 cannot be expected to compete efficiently against the SpaceX Falcon.

The Airbus Group's chairman/CEO, Tom Enders, and his Safran counterpart, Jean-Pierre Herteman, when unveiling their plan to rapidly establish a space joint venture, used highly diplomatic language, but the reality is significantly harder: This is obviously the first phase of a major consolidation move involving job cuts.

Airbus Group and Safran top executives will seek to assert their freedom of action and, although acknowledging the need to work closely with ESA, will more than ever carefully avoid political interference. This will not be an easy goal, as shown at the event when their agreement was unveiled: The meeting took place at the Elysee Palace and French President Francois Hollande was the star of the show. This says it all.

Now will come technical disagreements, such as solid propulsion versus liquid fuel. In December, ESA member states' space ministers will meet to review the Ariane program's latest development, including the upgraded 5ME derivative and the envisioned next-generation Ariane 6. Divergent views on technicalities are expected to make discussions difficult, while participants will certainly still be shaken up by the consolidation-related news. The wake-up call is salutary, but devastating. ☹



COMMENTARY

## Crossing the Ts

### Regulators and industry strive to close flight-tracking ambiguities

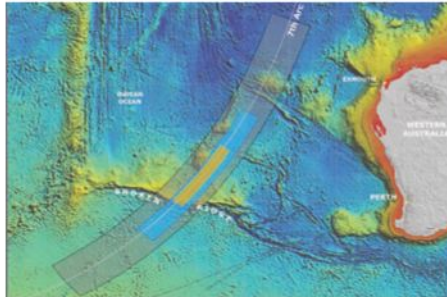
**T**he global aviation community is out to close a loophole the size of the southern Indian Ocean, the most likely resting place for Malaysia Airlines Flight MH370. Annex 6 of the International Civil Aviation Organization (ICAO) calls for aviation regulators in member states to require their airlines to know where their aircraft are located.

However, a survey of member and nonmember airlines, initiated as part of the post-MH370 rush to implement global tracking standards, reveals that “some airlines don’t track,” says Dorothy Reimold, aircraft tracking project manager for the International Air Transport Association (IATA).

The omission is not all the fault of the airlines. Existing Annex 6 tracking requirements “are very soft” and unclear, says Nancy Graham, director of the ICAO’s air navigation bureau. Graham says the rules are not enforced, and the organization only finds out about the issue during audits of member states. “There is a requirement, but we’ve never exercised [it],” she says, adding that one major drawback has been the drafting of a concept of operations that everyone endorses. “Not all airlines know where their aircraft are,” says Graham. There are reasons for that, she says, some of which relate to technology and procedures.

IATA launched the tracking survey via its aircraft tracking task force, a joint effort with ICAO, to help airlines voluntarily begin using largely existing avionics to trace their aircraft. Most widebody aircraft are already equipped for tracking, principally through satellite links to air navigation service providers and airline operations centers. “They need to turn it on and agree to some concept of operations,” says Graham.

The task force is developing a concept of operations (conops) that will include “a clear definition of the objectives of flight tracking that ensures



AUSTRALIAN TRANSPORT SAFETY BOARD

information is provided in a timely fashion to the right people to support search and rescue as well as recovery and accident investigation activities, along with the roles and responsibilities of all stakeholders,” says ICAO.

The draft conops is due in September, with ICAO ideally approving the measures at a special safety meeting in February 2015.

IATA will also be a key player as ICAO crafts performance-based global standards for tracking over the next two years, and more comprehensive surveillance options for the longer term—including remote storage of flight information. The rules flow down to member nations to implement.

Industry and government resolve was cemented at an ICAO special meeting on global tracking in May, attended by 207 participants from 44 member nations as well as industry representatives. “MH370 was a call to action for the entire aviation community,” says Graham. “[There was a] global agreement that we need to track aircraft regardless of where they took off from to where they were going.”

Graham says that due to “ICAO’s limitations and the time it would take,” both regulatory agencies agreed before the meeting to a two-step process; IATA has consented to a voluntary implementation of tracking, initially, while ICAO will develop a global standard on a parallel track.

“The idea of the airlines volunteering to move out quickly is that they have the capacity to do so and are willing to so . . . at the same time we proceed with a global rule [that] is more straightforward than Annex 6 is today,” says Graham.

The task force’s June meeting primarily concentrated on tracking system vendors’ presentations of existing “baseline” capabilities. To help determine the current state of tracking in the industry, airlines were polled to find out what they are doing in terms of flight tracking, what they are planning to do, or whether they are even considering measures, says Reimold. The task force also is surveying air navigation service providers to understand today’s surveillance network. “Even in today’s environment, what we see is a very complete quilt in some parts of the world and a very inexact fabric in other parts of the world,” she says.

“We are looking to define the current state,” Reimold continues, because “we need to know where the gaps are so we can prioritize those in our recommendations [to ICAO].” She says another focus of the task forces will be to establish criteria for any products and services to meet some baseline criteria.

While the work might close one loophole, another could remain open. The tracking standards will not, at least initially, include safeguards for preventing tampering, which is one possibility in MH370’s lost-voice-and-data contact with controllers and the airline. Officials are now focusing the search on the southern Indian Ocean (see map). No extra equipment is needed for global tracking, says Graham. “Turn it on. That’s all we need to do.”

Reimold emphasizes that IATA’s task force recommendations will not prevent another accident from happening. Potentially, “it will help to more quickly locate the aircraft,” she says. ☛



Senior Editor Frank Moring, Jr., blogs at: [AviationWeek.com/onspace](http://AviationWeek.com/onspace)  
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## COMMENTARY

# Man in the Loop

## Life support in space holds lessons for the Earth

International Space Station crewmates are looking forward to a little more fresh food with their processed nutrition, thanks to a new plant-growth chamber delivered by the most recent SpaceX Dragon to reach the orbiting outpost. Developed by Orbitec in Madison, Wisconsin, the “Veggie” unit is a very small farm—11.5 X 14.5 in.—that will allow the crew to grow red romaine lettuce for researchers to evaluate and them to eat. Like much of the work on the ISS, the “Veg-01” experiment is aimed at the thorny problem of keeping deep-space explorers alive on long-duration missions to Mars.



ESA

“Those plants can help with carbon dioxide removal and generating some other products that are beneficial to us, as well as providing a food source,” says William Gerstenmaier, associate NASA administrator for human exploration and operations (HEO).

Engineers working for the HEO and space-technology NASA mission directorates have a huge task ahead of them in environmental control and life support systems (Eclss) as they prepare for a Mars mission, and Veggie is just a part of it.

“When we go to Mars, this will be a definitively closed system,” says Sam Scimemi, the ISS program director at NASA headquarters. “There will be no resupply. There will be no repair parts. There will be no ground analysis. It will all be closed within the spacecraft and the humans together to go to Mars.”

The unique station environment is the only place to test Eclss hardware for that long journey. The ISS has “dis-similar redundancy”—a key concept in exploration architecture (*AW&ST* June 23, p. 29)—in its U.S. and Russian life support, but it must rely on its proxim-

ity to Earth for the consumables that make the systems work.

“Our life support system is about 86% closed now,” says Gerstenmaier. “We recycle urine. We recycle moisture out of the atmosphere. We take waste carbon dioxide and generate more water from that, and then the waste gas that comes out of it is methane. So everything is fairly closed cycle.”

That is not good enough for a Mars mission. On top of the recycling shortfall, station engineers are learning that today’s Eclss hardware has an engineering oversight that must be corrected before the life-support loop can close. The problem centers on the urine recycling system, which processes the human waste into potable water. It is a complicated piece of gear that requires careful maintenance (see photo), but it works—up to a point.

“With the urine processor, we can only recycle so much of the urine because we end up where, essentially, the brine that’s generated clogs up all our pumps, and stops the system from working and operating,” Gerstenmaier says.

NASA engineers are trying to

find ways to wring the last drops of moisture from the brine, Gerstenmaier says, but that addresses the symptom instead of the underlying problem: the humans who drink the recycled water, and what happens to their bodies when their bones no longer have to support them in Earth’s gravity.

“It turned out, when we were having all the bone-loss problems, [that] the biggest constituent of the urine was actually bone, or calcium,” Gerstenmaier says. “And that was causing all our pumps to clog up. So here the humans [are] destroying the mechanical system that’s supposed to provide water for them. It’s the ‘perfect system the engineers built,’ because we tested with reference urine on the ground, which didn’t have the high calcium content because nobody had that high a calcium content on the Earth. So the standard urine that you get to practice with wasn’t really urine that was on board [the] station.”

For Gerstenmaier, the lesson is to pay more attention to the crew’s biological output as well as the air, water and other inputs Eclss must provide for their survival. “I think we need to look at it as more of a system than we have before,” he says. “It’s intriguing when I think about this; the human is really now a piece of the spacecraft.”

NASA and its ISS partners are paying close attention to lessons like this, which illustrate the station’s utility as a laboratory for deep-space exploration. The upcoming year-long stay by astronaut Scott Kelly and cosmonaut Mikhail Kornienko will be a chance to learn more.

Of course, there is another lesson in the urine-calcium discovery, and it is as plain as the changing blue Earth spinning below the windows of the station cupola. In the 60-plus years that we have been observing Earth from space, the human impact has been on view in the growing urban sprawl, dwindling forests and melting polar ice. Sophisticated instruments that view the invisible effects of human activity on the planetary Eclss only underscore what the astronauts see. As an engineer, Gerstenmaier gets it.

“It couples right back here to the Earth,” he says. “The Earth is the ultimate closed system, and how do we do things that perturb the Earth? And don’t realize what they do? And they have long-duration impact.” ☼



## COMMENTARY

# Enumerated Rights

## Senator takes off on second sortie to assure general-aviation pilots' rights

**T**wo years after he ushered his "Pilot's Bill of Rights" into law to bolster private pilots' positions during federal enforcement actions, the Capitol's leading everyman-aviator advocate, Sen. James Inhofe (R-Okla.), wants to further amend the list.

Inhofe, a member of the Senate General Aviation Caucus, has started pitching a second bill that addresses third-class medical requirements and a number of other issues. The senator is a pilot whose life has been intertwined with aviation, including the loss of his son last year in a crash and his infamous landing on a closed runway in 2010. He released details of his proposal recently and is seeking comments from the aviation community to help shape final legislation, including at an Aug. 2 forum during the Experimental Aircraft Association's (EAA) AirVenture in Oshkosh, Wis. The deadline for feedback is Aug. 8.

"I have heard from the aviation community that more improvements still need to be made to cut red tape," Inhofe says. The second bill is designed to continue to chip away at "unfair practices and regulations," he says.

One goal of the new "Pilot's Bill of Rights" is to expand the third-class medical exemption to most small GA operators. The Aircraft Owners and Pilots Association and EAA both have petitioned the FAA for the exemption, and legislation was introduced in both the House and Senate. But the Aerospace Medical Association is among those expressing reservations about any change. The FAA has promised a full-blown rulemaking procedure to explore the change.

Inhofe's measure also would include language to "rein in" Customs and Border Patrol stops and searches, give airport officials more authority



DPA/LANDOV FILE PHOTO

**'More improvements still need to be made to cut red tape.'**

—SEN. JAMES INHOFE

over private hangars, and try to ease the approval process for retrofit of safety enhancing equipment on existing aircraft. It further would prohibit enforcement of Notice to Airmen violations if the FAA has not finished its Notam improvement program by year-end, and would open outsourced FAA programs to Freedom of Information Act requests. These requests were established in the 1960s to help pry information from government agencies, but much government work has been outsourced to private companies in recent decades.

Finally, the bill would expand on the original law by making it clear that pilots can appeal FAA investigations directly to a U.S. district court. Inhofe says a related provision in the original law "has not operated as intended." It also would expand protections to other certificate holders, including charter operators and repair stations, and require the FAA to provide notifications to individuals under investigation and limit the scope of the documents it could request. ☛

### SHRINKING PIE

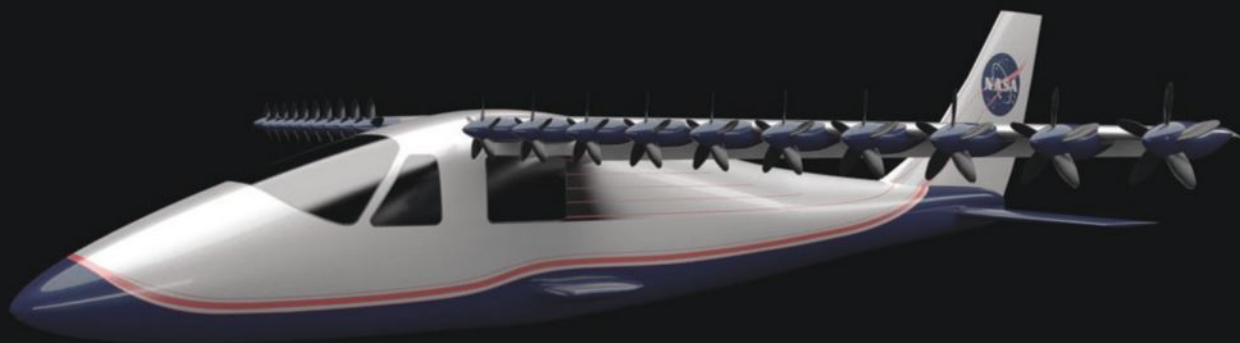
Long dreaded by the defense industry, a significant ramping down of war-related supplemental budgets has begun with the Obama administration's

outline of its fiscal 2015 request. The White House submitted a summary in late June—although not yet actual legislation—to lawmakers of its Overseas Contingency Operations (OCO) budget for the year starting Oct. 1.

The Defense Department's \$58.6 billion proposal for operations in Afghanistan and elsewhere came in \$20.9 billion less than the \$79.4 billion placeholder outlined in early March. It also pales in comparison with the \$85 billion in OCO appropriated for this fiscal year. In turn, more headlines could emerge about major moves in industrial ranks. With publicly traded defense contractors preparing to host their quarterly teleconferences on financial results later this month, the new budget request, and the falloff in funding it represents, could feature prominently in management discussions about the next few years—especially as industry has become fairly dependent on large OCO budgets (AW&ST May 12, p. 25).

So who stands to win or lose, relatively? According to analysis by Washington defense consultant Jim McAleese of McAleese and Associates, the biggest winners include: Air Force procurement of aircraft, missiles, classified programs and depot maintenance; Navy and Marine Corps research and development, weapons and ammunition procurement, and shipbuilding; and Army war-related "reset" or maintenance, repair and overhaul work as well as combat trucks and electronics for soldiers. Other Pentagon-wide initiatives also receive support, including a new counterterrorism fund, a boost to U.S. forces in Europe and Special Operations Forces.

The big losers include: Air Force war-related operations and maintenance (O&M) spending, airlift operations, Air Combat Command primary fighter forces and logistics; Navy and Marine aircraft procurement and O&M, including depot work; and Army R&D overall, aircraft and ammunition procurement, war-related O&M—effectively cut in half—and numerous theater-level combat forces, including aviation and their related maintenance. Pentagon-wide R&D and O&M also lose, in relative terms. ☛



# Electrifying Aviation

Light aircraft are early targets for the efficiency and safety benefits touted for electric propulsion

Graham Warwick **Atlanta**

**A**viation did not enter the Jet Age overnight, and a decades-long journey to the next propulsion paradigm may already be underway. At NASA, the exploration has begun with plans for ground and flight tests to determine whether hybrid and distributed electric propulsion could be the next disruptive shift in civil aviation.

A wing carried high above a truck racing across the dry lakebed at Edwards AFB, California, in November could provide the first validated data to prove that distributed electric propulsion can offer the promised benefits. The 31-ft.-span wing will carry 18 small electrically driven propellers, and is a precursor to a small X-plane demonstrator proposed under NASA's new Transformative Aeronautics Concepts program.

In parallel, over the next five years, the agency wants to develop technology for compact, high-power-density electric motors generating 1-2 megawatts—sufficient to power an all-electric general-aviation aircraft or helicopter, a hybrid turbine-electric regional airliner or a large transport with many small engines distributed around the aircraft in ways that make it safer and more energy-efficient.

The sweet spot for a first generation of electric-powered aircraft seems to be between 1 and 2 megawatts, says Ruben Del Rosario, NASA Fixed Wing program manager. But the agency also sees an intersection of unmanned and

personal air vehicles around electrical propulsion and increasing autonomy, beginning this spiral exploration with small unmanned aerial systems (UAS) (see page 20) and light aircraft.

“What problems are we trying to solve in general aviation?” Mark Moore, advanced concepts engineer at NASA Langley Research Center, reflects. His answer is many, and they encompass the low efficiency; poor safety, emissions and ride quality; and high operating costs of some light aircraft and helicopters.

Distributed electric propulsion promises dramatic increases in aerodynamic and propulsive efficiency, and reductions in noise and energy costs. “It is not just about general aviation, but they are earlier adopters at a smaller scale, faster and cheaper,” Moore says.

Electric propulsion is not without its penalties. Energy-storage weights are far worse than those of aviation fuel, and battery-pack costs are high. But electric motors are more efficient than turbines or pistons across a wide rpm range, and power-to-weight ratios are higher; they are quiet, compact and re-

**Modifying the wing on a Technam P2006T light twin would directly compare distributed electric and conventional propulsion.**

liable, with zero emissions and energy costs that are much lower than for aviation fuel. And, crucially for aircraft design, efficiency and power-to-weight are independent of size.

“You can have multiple small electric motors with the same output as a large one without much penalty. You can put them anywhere around the aircraft, versus heavy piston engines that can only go in one or two places,” says Joby Aviation’s Alex Stoll, chief designer of the Lotus small UAS and two-seat S2, both vertical-takeoff-and-landing designs using distributed electric propulsion. “You can use them to make a personal air vehicle practical, versus an expensive, noisy, unsafe helicopter.”

To test the premise that the tighter propulsion-airframe integration possible with electric power will deliver efficiency, safety and environmental and economic benefits, NASA has partnered with Empirical Systems Aerospace (ESAero) and Joby to propose the Leading Edge Asynchronous Propeller Technology (LEAPTech) demonstrator as an X-plane testbed for distributed electric propulsion.

A traditional light aircraft needs a large wing to meet the low stall-speed requirement for certification, but this

is inefficient in cruise. LEAPTech replaces the big wing with one that is one-third the size for lower drag, and has three times the wing loading for better ride quality. Cruise lift-to-drag ratio at 200 mph is greater than 20, versus 11 for a comparable Cirrus SR22, NASA estimates.

To achieve the required 61-kt. stall speed with such a small wing, LEAPTech mounts an array of small propellers along the leading edge. These accelerate airflow over the wing, increasing dynamic pressure at the leading edge and more than doubling the maximum lift coefficient ( $C_{L_{max}}$ ) at low speed. "In computational fluid dynamics, we have seen lift coefficients of 5.5. We need 4.5 for a 61-knot stall," says Stoll. Unblown, with full-span Fowler flaps deployed 40 deg,  $C_{L_{max}}$  is 2.7, says Moore.

Optimized for low speed, the small-diameter, high-solidity propellers have low tip speeds, around 450 ft./sec. compared with an SR22's 919 ft./sec., for reduced noise. In addition, they all operate at slightly different speeds to spread the frequencies and reduce the annoyance. The props blow the wing for takeoff and landing, but fold back to reduce drag in cruise, at which point wingtip propellers optimized for high speed provide propulsion, operating inside the wingtip vortices to increase efficiency.

The intent of LEAPTech is to modify a Tecnam P2006T light twin with the new wing, to provide a direct comparison between conventional and distributed-electric propulsion. But the first step is the Hybrid-Electric Integrated Systems Testbed (Heist), a truck-mounted rig that will enable NASA to ground-test a full-scale wing

at the 61-kt. stall condition at lower cost than a wind-tunnel test.

"NFAC [National Full-Scale Aerodynamics Complex wind-tunnel facility] would have cost more than the entire budget [for Heist]," says Moore. "And we need to get to this scale to have reasonable data." The wing will float on an airbag system in the truck to minimize vibration from the lakebed, and the remaining noise will be removed during post-processing to obtain lift measurements with less than 5% error, he says.

ESAero is the prime contractor for Heist. Joby Aviation is building the test rig, wing, motors and props. Combined, the 18 propellers will generate 300 hp and the wing will provide 3,500 lb. of lift. ESAero will conduct shakedown tests on a paved runway before the lakebed tests in November. "We will get ground vibration . . . [but] are confident we can get clean data on lift, drag and pitching moment," says NASA Armstrong Flight Research Center project engineer Sean Clark.

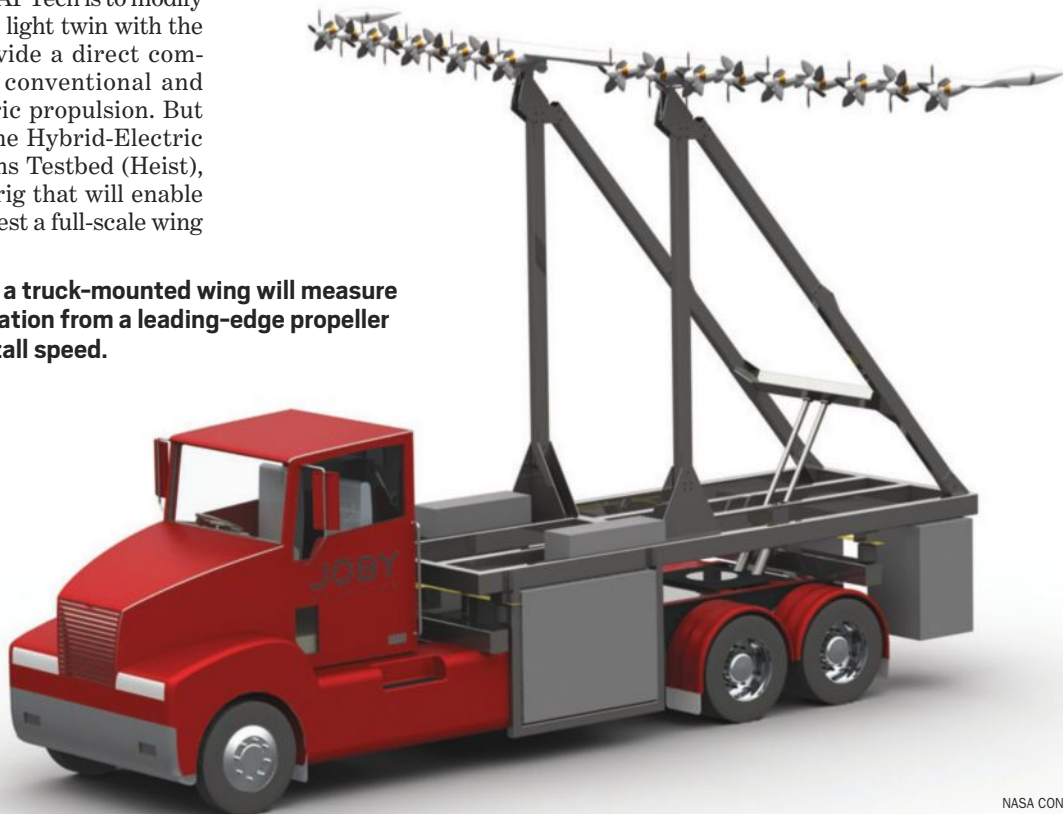
In parallel, NASA is beginning fundamental research to understand and overcome the challenges of electric propulsion. Now taking shape at Armstrong, the Airvolt test stand will be used to characterize each element of a single-string propulsion system,

from batteries to propeller. A year from now, this will be upgraded to the Airvolt Hybrid, with a Rolls-Royce M250 turboshaft, electric motor/generator and enlarged batteries. This will be arranged so that both the gas turbine and electric motor can drive the propeller, and will be used to look at power-transfer stability issues with parallel hybrid propulsion.

In February 2016, NASA Armstrong plans to begin the Heist power management and distribution (PMAD) ground demonstration. This will be a static propulsion test stand co-located with Airvolt and used as a long-term research platform. NASA plans to evaluate stability issues inherent in parallel-hybrid electric bus architectures, characterize aggregate thrust control of many motors, investigate algorithms for thrust-augmented yaw control and to assess power generation and consumption problems such as catastrophic load shedding, says Clark.

"We will take the wing off the truck, put it on a static test stand and start to do power distribution studies," he says. These will include shifting between batteries and turbine-driven generator feeding the distributed power bus, and stabilizing the high-frequency electrical loads from the motors. "We will

**Runway tests of a truck-mounted wing will measure the lift augmentation from a leading-edge propeller array at 61-kt. stall speed.**



NASA CONCEPT

study how to schedule power for yaw control, and how to integrate prognostic health monitoring," including sensors on the motors, Clark says.

A distributed propulsion electronic controller will translate thrust targets input by the pilot into individual thrust commands for each of the propulsors, while managing the balance between power generation, storage and consumption. A control algorithm will manage the loading of the generator, real-time capacity of the energy stor-

age buffer and power demand from the collection of propulsors. Another algorithm will synthesize individual propulsor commands based on total thrust targets and generator- and stored-power availability.

Heist will use 100-120-volt electrical systems. "That's not optimal, but it allows us to do [Heist] within a year, and we do not care about weight," says Andrew Gibson, ESAero business-development president. NASA plans to move to a 600-volt system to reduce distribu-

tion wiring weight. "It's the sweet spot; [there are] no arcing concerns and components are available today," says Clark.

To follow PMAD, NASA plans hardware-in-the-loop tests to integrate flight-like electric propulsion hardware with simulated aircraft flight controls. Next up will be aircraft-in-the-loop "iron bird" tests with real controls surfaces, flight-ready control system and flight-like energy storage components. The iron bird would test systems for a kilowatt-class distributed electric

# Vertical Electric

## Propulsion revolution starts small, with prototype hybrid-electric vertical-takeoff UAS

Graham Warwick **Atlanta**

**A**mong the first steps to energy-efficient hybrid-electric distributed propulsion are two small unmanned-aircraft prototypes being tested under a NASA program. These cruise-efficient vertical-takeoff-and-landing (VTOL) UAS represent the first turn in the agency's spiral development plan for electric propulsion.

The aircraft—NASA Langley Research Center's GL-10 Greased Lightning and Joby Aviation's Lotus—were designed in response to a request from an unidentified U.S. agency for a VTOL UAS with long endurance. Rotary-wing VTOL UAS eliminate the need for launch and recovery equipment, but typically have poor cruise efficiency compared with fixed-wing

UAS, which have long endurance, but need burdensome support apparatus.

NASA's GL-10 is a tilt-wing/tilt-tail configuration with thrust distributed both laterally and longitudinally to maximize airflow attachment over the tilted wing and tail during transition between vertical and horizontal flight. This arrangement also provides robust flight control for the demanding sensor-emplacement mission, says Mark Moore, an advanced concepts engineer in the aeronautic systems analysis branch at Langley.

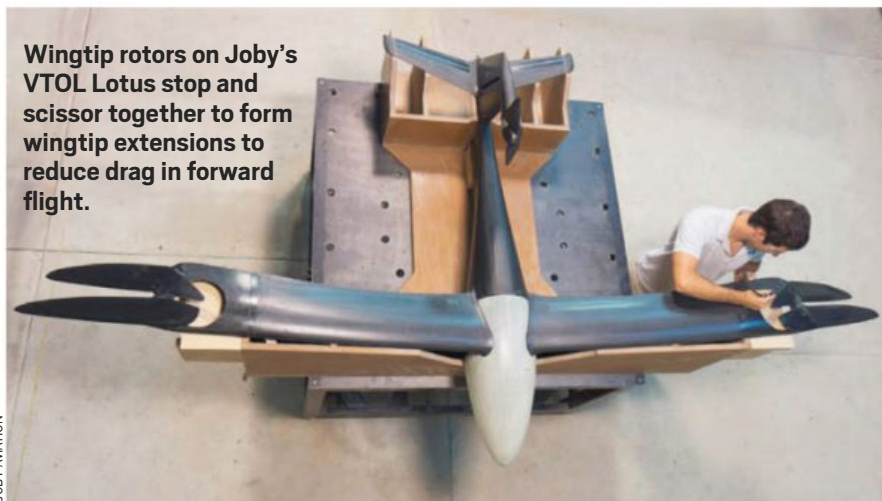
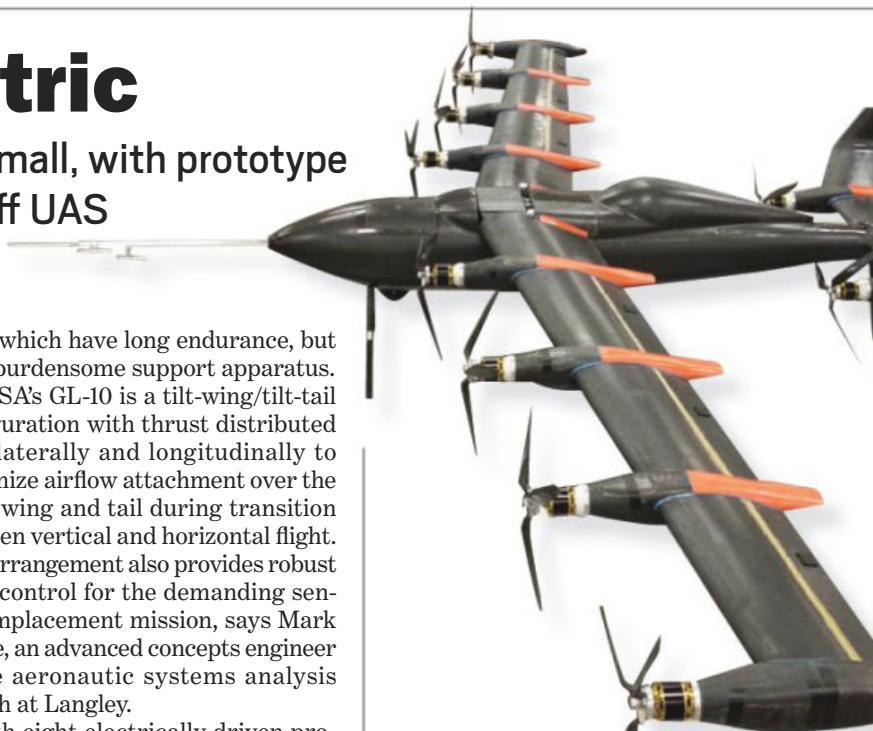
With eight electrically driven propellers blowing over the tilted wing, and another two blowing over the tilted tail, the aircraft is less prone to buffeting in transition between thrust-borne

and wing-borne flight than previous tilt-wing designs, mid-1960s Canadair one propeller per larger LTV XC-142 side still had sizable areas of stall and separated flow over the tilted wing during transition.

than previous he says. The CL-84 with two per side with the two per

Joby's Lotus is a "multifunction-rotor" tricopter design. For VTOL, electrically driven rotors on the wing and fin tips provide vertical thrust. To transition into forward flight, the fin-mounted rotor tilts down to become a propeller and provide propulsion while the wing-mounted two-blade rotors stop and scissor together to form fixed extensions to the tips. This results in higher hover and cruise efficiencies than the GL-10, says Moore, speaking at the AIAA Aviation 2014 conference here.

The rotors have low disk loading



Wingtip rotors on Joby's VTOL Lotus stop and scissor together to form wingtip extensions to reduce drag in forward flight.

propulsion X-plane, the LEAPTech, and a 1-2 megawatt hybrid-electric flight demonstrator, notionally one of NASA's Northrop Grumman RQ-4 Global Hawk unmanned aircraft.

Clark says the iron bird will be used to assess actual electric-propulsion implementation effects such as real-world volume and weight constraints, to address failure modes and recovery strategies, identify and resolve interdependencies between propulsion and other systems, validate aero-propul-

sive efficiency gains and demonstrate realistic performance benefits from propulsion-airframe integration.

While it seems futuristic, distributed electric propulsion is on the near horizon for light aircraft. Companies such as Joby and secretive Zee.aero are designing personal aircraft around the concept, knowing they must wait for batteries and motors to improve. Joby plans to fly the S2 in 1-2 years and certificate it in "a few years," says Stoll, who believes "by 2020 electric aircraft

will fly 500 miles at 200 mph."

Moore believes electric propulsion, coupled with autonomy, will spark a breakthrough in on-demand aviation and that the technology will move up to larger aircraft over time, because, just as "the PC came before the Internet, transformative vehicles lead transformative capabilities," he says. "As you go up in size, the benefits decrease because larger aircraft are already more efficient. But it is still compelling." ☛

### GL-10's multiple electric-driven props prevent flow separation on tilted wing and tail during transition between vertical and forward flight.

and low tip speed, just 330 ft./sec., which minimizes noise, and reusing their rotor lifting surface as fixed wingtips increases the lift-to-drag ratio to 19, compared with less than 5 for a conventional helicopter, says Alex Stoll, chief designer of the Lotus. Joby's design objective is a 300-lb.-class UAS with 24-hr. endurance.

Both concepts are to be flight tested in the form of 55-lb.-class prototype UAS with hybrid-electric propulsion systems combining two small heavy-fuel engines, advanced generators and battery packs. Each compact 8-hp two-stroke, two-cycle engine from GS Engineering drives a dual Halbach-array electrical generator developed for NASA by LaunchPoint Technologies.

Engine and generator produce a peak 6 kw in the hover and 1.5 kw in the loiter at a total weight of 13 lb.—8 lb. for the engine, 3 lb. for the generator and 2 lb. for the electronics. "We think we can reduce that," says Michael Ricci, vice president of engineering at LaunchPoint. A Halbach array is an arrangement of permanent magnets that reduces weight and losses, and results in an axial-flux machine with pancake-shaped rotors that create the airflow to cool the stator. LaunchPoint is aiming for an efficiency of 95% from engine shaft to DC bus, and believes the generator should be able to produce 10 kw in bench tests, Ricci says.

NASA says the Langley and Joby concepts achieve vertical flight capability with dramatically higher cruise

efficiency than existing VTOL UAVs, and can provide four times more endurance without waiting for improvements in battery technology.

Sub-scale 25-lb.-class rapid prototypes have been flown to demonstrate conversion, and the 55-lb.-class ve-

hicles are now in ground and hover testing; transition flights are planned for later this year. The small UAVs will provide a stepping-stone to larger hybrid and distributed electric propulsion concepts that NASA plans to test on the ground and in flight. ☛

## AIR TRANSPORT

# Life Extension

## Boeing hopes further improvements will make the 747-8 more attractive for passenger airlines

Guy Norris **Los Angeles** and Jens Flottau **Seattle**

**T**he 747-8 has given Boeing more than one reason for concern. But a renewed sales push and technical upgrades are intended to ensure production rates can slowly increase again.

Boeing is "very close" to reaching deals in sales campaigns for the 747-8 that would fill some empty production slots in 2016. "We want to be back at rate 1.75," says 747 Vice President and General Manager Eric Lindblad. He declines to disclose the exact split between freighters and passenger aircraft but adds that "there are a lot of Intercontinentals in the conversations that we are having."

According to industry sources, Boeing is talking to up to four airlines in Asia and Europe about a potential order for the type. By contrast, Lindblad concedes that demand for the freighter version is still weak: "The freight market has to become better before we see a ton of activity." Boeing is currently at a rate of 1.5 aircraft per month. "We expect the

market to be in parity [equal sales of passenger and freighter aircraft] by 2016. That's when we expect freighter sales to pick back up," Lindblad says.

Sales of the 747-8 have lagged far behind initial expectations. Boeing has reached 120 firm orders, and 69 aircraft have been delivered so far. After Lufthansa, Air China will become the second passenger airline to take delivery of a 747-8 later this year—its first aircraft is receiving its interiors on the Everett final assembly line—and Korean Air is to follow in 2015.

Boeing has been pitching the aircraft to Emirates Airline for flights from Dubai to the U.S. West Coast, but Emirates Airline President Tim Clark has publicly discarded the idea. Emirates flies the Airbus A380 and Boeing 777 to destinations on the West Coast now. Turkish Airlines also has been named as a potential 747-8 operator.

As part of the campaigns, Boeing is still talking to airlines about 747-8

improvements that have been defined in "Project Ozark," some of which have already been introduced. "We can have an aircraft that can do 8,200 nautical miles if we have the right customers," Lindblad says. The current 747-8 has a design range of 7,700 nm with full reserves and 467 passengers. All of the Ozark improvements combined would lead Boeing to raise maximum takeoff weight (MTOW) beyond 1 million lb. from the current 987,000 lb.

"We have not launched Ozark, but we have taken items off the list," Lindblad

says. Computer (FMC) modernization, among others. Boeing has so far reached a 9,000-lb. weight reduction and wants to reach 10,000 lb. before year-end. That target was originally planned to be reached only in 2016.

In 2013, the empty weight of the aircraft was a bit more than 7,000 lb. lighter than when the 747-8 first entered service in 2011. "Now it has grown to 9,000 pounds. I don't think we will stop at 10,000 pounds," Lindblad says.

"The max zero fuel-weight reduction currently offered for the -8F is outside

"Those are the major pieces of the menu," Lindblad says. "We will still go after some of the smaller aero packages, but the wing-to-body fairing is a fairly large-scale job, so we'd probably wait to see if we need to get to 8,200 nautical miles. It is the same with the MTOW. We will wait to see if we need to do that. So far, we would have to have a launch customer, and it is a sizable investment."

Boeing is also continuing to drive improvements in the production system that will help keep costs in check

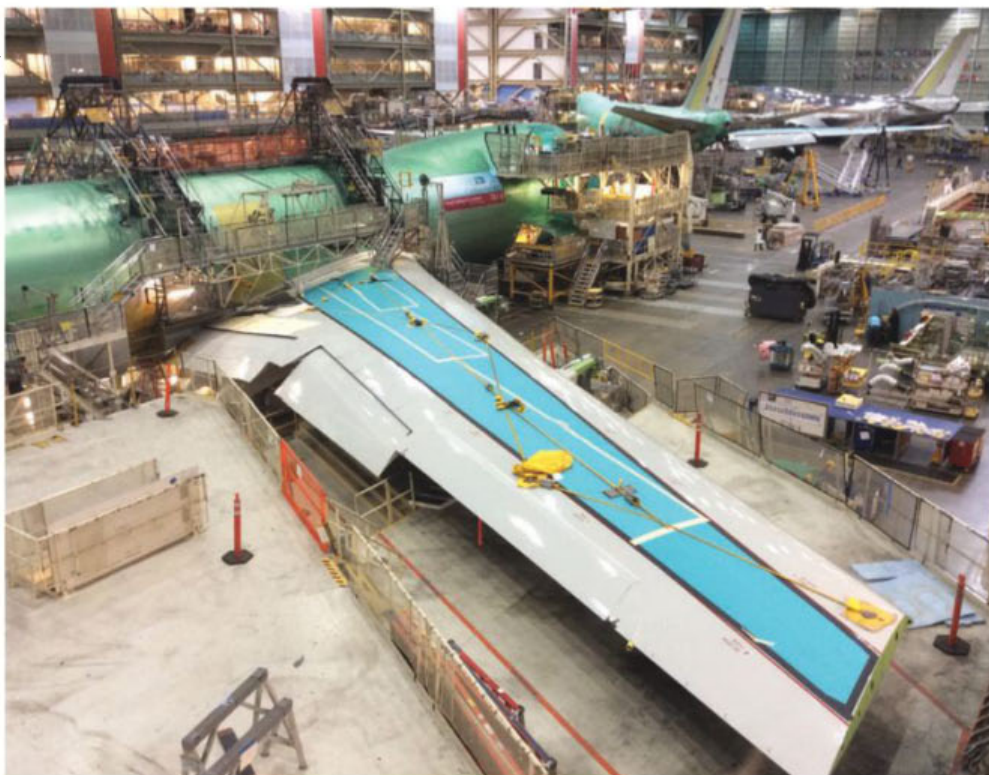
despite production volumes that are lower than hoped. "It has finally started to stabilize following the difficult years during the development cycle," Lindblad says. "We were equivalent of about four days behind schedule and today we are about 1.5 days behind schedule. So, with stability, we see that giving us the opportunity to drive down operational

**Boeing would like to raise the 747 production rate to 1.75 from 1.5 aircraft per month.**

costs. We have had a chance to drive flow reductions and improve operational efficiency within each area of the factory and start to now look at other things that allow efficiency to take place."

These include improvements to the process used to fasten fuselage lap-splice

joints where two panels come together with three rows of fasteners. "On the 747, all of those are done with a human, and in June we started going through the validation cycle to use flextrack drillers, which are used on the 777 now," Lindblad says. "It is our intent to use this technology across the majority of the 747 fuselage lap-joints as well as the circumferential joints. We will start first with lap joints across forward [Sections 41/42] and aft [Sections 46/48] in subsequent phases, and while we are doing that will bring in circumferential joints beginning with the aft joint in Section 44. We are not only investing in the product but also the production system. There is a lot of time left on this aircraft." ☐



says. Aircraft coming off the line today are 3.5% better in terms of fuel burn than the aircraft initially delivered. Lufthansa, which took delivery of its 14th 747-8 at the end of June, says the aircraft is now meeting the performance specifications guaranteed by Boeing. The airline has 19 747-8s on firm order.

According to Lufthansa's executive vice president for fleet management, Nico Buchholz, the in-service fleet can be upgraded to reach a 2% improvement mainly by bringing engines up to the performance improvement package (PIP) standard during shop visits. But he says, "we want to see further improvements."

Upgrades already implemented include the PIP, the tail fuel tank activation and a flight management com-

puter (FMC) modernization, among others. Boeing has so far reached a 9,000-lb. weight reduction and wants to reach 10,000 lb. before year-end. That target was originally planned to be reached only in 2016.

The overall goal is "primarily about overall efficiency; it would not be a specific fuel-consumption improvement on the engine," Lindblad says. "It would include an aerodynamic component and continued weight improvements as well as a maximum take-off weight increase." The aerodynamic improvements encapsulated within the Ozark package include "some of the fairings adjacent to the horizontal tail [and] the wing-to-body fairing, and in the scalloped area of the thrust reverser," he adds. The upgrade would focus on "thinning" of the chevrons on the trailing edge of the GENx-2B nacelle.

# Rightsizing Exercise

Sukhoi is looking for ways to make the Superjet more competitive

Maxim Pyadushkin **Komsomolsk-on-Amur, Russia**

**S**ukhoi Civil Aircraft Co. (SCAC) is increasing production rates of its Sukhoi Superjet 100 regional aircraft, but an increase in competition in the segment has the manufacturer striving to find ways to improve its only product.

SCAC representatives explain that the influx of so many new entries into the global regional aircraft market has impelled them to study improved operational capabilities for the SSJ100. SCAC Deputy Chief Designer for Aerodynamics Alexander Dolotovskiy says the next aerodynamics improvement will be the introduction of winglets. SCAC has already conducted wind-tunnel tests with the various winglet shapes being considered. The chosen variant aims to improve the aircraft's fuel efficiency by 3%. Dolotovskiy hopes this will make the SSJ100 competitive with the Embraer E-Jet E2 family from a fuel-burn perspective. Winglet installation is scheduled to begin in 2016-17. The manufacturer says winglets can also be retrofitted to in-service aircraft.

SCAC is still working on a stretched version of the SSJ100. The new variant is likely to have a maximum take-off weight (MTOW) of 53 tons and accommodate 100-130 passengers. The current SSJ100 has a MTOW of 45-49 tons and can carry up to 103 passengers in an all-economy configura-

tion. The basic layout of the stretched aircraft is to be decided in 2015. This version will require a new wing, but it will be based on the same technologies, says Dolotovskiy. An engine has not yet been selected, but a version of the current SaM146 is a possibility. This powerplant has two different thrust versions now—17,300-lb. thrust for SSJ100 basic and 17,800-lb. thrust for the long-range variant.

SCAC has also worked on a more significant modernization of the aircraft—the Superjet NG program—which was slated to involve new capacity, avionics and engines. But this program has been suspended until 2016 due to lack of government support.

Twenty-five of the current model were rolled out of the production facility in Komsomolsk-on-Amur in Russia's Far East region in 2013, and the goal for this year is 40. Since the beginning of the year, the plant has manufactured 15 airframes. They were flown from Komsomolsk-on-Amur to completion centers in Venice, Italy, and Ulyanovsk, Russia. The former is operated by SuperJet International, a joint venture of Sukhoi and Alenia Aermacchi, that is preparing the SSJ100 for its first Western customer—Mexican carrier Interjet.

The Ulyanovsk center largely caters to Russian and Asian-based customers.

The current assembly time in Komsomolsk-on-Amur is 10 days per aircraft. But in the second half of the year this will be reduced to seven days per airframe, Dmitry Bloshinsky, director of the branch, says. Various elements of the SSJ100 assembly line have been tested for the increased rate. SCAC does not plan to expand the assembly line itself. It currently consists of six stations, but the fuselage assembly area, which now has four workstations, will become bigger. The rate increase has been made possible because of better employee training, improved logistics and application of lean-manufacturing techniques, according to Bloshinsky.

The increased production rate will require corresponding efforts by the program's suppliers. Fuselage sections and components come from other facilities run by United Aircraft Corp.—SCAC's parent company—in Komsomolsk-on-Amur, Ulyanovsk and Voronezh. The program also involves more than 70 Russian and foreign suppliers.

Production of SAM146 engines will be increased to 10 from eight per month, according to Georgy Konyukhov, deputy head of design at Powerjet. The joint venture between France's Safran and Russia's NPO Saturn delivers the engines from its production line in Rybinsk.

The efforts will enable SCAC to build 40 SSJ100s in 2014 and 50 in 2015, says Bloshinsky. The maximum production capacity of the Komsomolsk-on-Amur facility is 60 airframes per year. The SSJ100 program has 182 firm orders at the moment; about 50 aircraft have been produced so far. ☼

**Mexican low-cost carrier Interjet is the first Western operator of the Sukhoi Superjet 100.**



# Low-Cost Conversions

## China should have four budget airlines by year-end

Bradley Perrett **Beijing**

**T**he Chinese air transport sector's move into budget aviation is gathering strength, with China Eastern Airlines setting out plans for a low-cost carrier while Hainan Airlines plans widespread adoption of the model by its subsidiaries. Air China, meanwhile, is looking at converting one of its subsidiaries into a budget carrier.

China Southern Airlines is now alone among the country's four big carriers with no known strategy for responding to calls from the Civil Aviation Administration of China to promote low-cost aviation.

Beijing-based China United Airlines will convert itself into a budget carrier, it and parent China Eastern said July 2, con-

the Yangtze River Delta, dominated by Shanghai, the home of Spring Airlines, and the Pearl River Delta, which includes Guangzhou.

Although Capital will join the Beijing-centered market, it will fly from a different airport, Beijing Capital International. China United is based at Beijing Nanyuan Airport, a military field at which the air force allows limited civil operations. Beijing also attracts tourists, Tang says, implying that much of China United's traffic is expected to originate elsewhere.

To get into low-cost aviation, Air China will also take the route of converting a subsidiary, says an industry official familiar with its plans. The identity of the subsidiary is not known and may not have been decided.

Hainan Airlines sees low-cost operations as the main direction of development for its subsidiaries, says a senior industry official. This includes Tianjin Airlines, which has decided to remove first-class seating from its Embraer E-190s.

That carrier, and maybe some siblings, will not be fully committed to budget operations, however. Premium seating will stay in Tianjin Airlines' Airbus A320s. And any conversion of operations may be obscured by branding. Prestige-seeking local governments that subsidize many air services in China will not like the sound of "low-cost airline," so subsidiaries of Hainan Airlines will look for other tags for their no-frills services, such as "all-economy." West Air is already firmly labeled as a low-cost carrier, however.

Managers at China United will be feeling their way in running low-cost operations, says Tang, in contrast to the Jetstar Hong Kong plan, in which China Eastern staff would work alongside and learn from Jetstar people with deep experience in budget aviation. Asked whether China United's management team includes anyone with experience in the new field, President Wang Lanhai says it has studied foreign companies and would not necessarily benefit from having outsiders onboard.

China Eastern owns 100% of China United and says it will build an integrated group combining full-service and low-cost operations—suggesting something like the successful Qantas-Jetstar mode of operations in Australia, in which top management flexibly deploys two brands in a single network. But that seems not to be China Eastern's aim, because it also says China United will run itself independently. Tang adds that China United may compete with the parent company on some routes.

China Eastern and Qantas established Jetstar Hong Kong as a joint company in 2012, but the Hong Kong government has so far withheld permission for it to begin flying. Dominant Hong Kong carrier Cathay Pacific and its subsidiary Dragonair object that the Jetstar franchisee does not have the local characteristics required by the city's constitution.

China United looks likely to begin budget operations this year. It will keep first-class seats, equivalent to Western business class, in its current 737s but configure future aircraft, supplied from China Eastern orders, with all-economy cabins. New aircraft will arrive this year, the carrier says. China United has other types in its fleet that are used for official charters, probably for the armed forces. ✎



All-economy-class Boeing 737s are due to enter the China United fleet this year.

firming Aviation Week's report of the plan (*AW&ST* Dec. 30, 2013, p. 16). China United will serve as its parent's experiment in budget aviation while the originally intended guinea pig, Jetstar Hong Kong, languishes without approval to begin flying. State-owned China Eastern expects to build China United's fleet to 80 Boeing 737s by 2019 from the current 26.

Probably not far behind is Capital Airlines, a Beijing-based affiliate of Hainan Airlines in the HNA Group that industry officials say has decided to become a low-cost carrier, though it has not announced its plans. Hainan Airlines converted subsidiary West Air in Chongqing last year to the budget model, joining pioneer Spring Airlines in the sub-sector. By year-end, Juneyao Airlines budget offshoot 9 Air should have begun flying from Guangzhou. Adding China United, there will likely be four Chinese mainland budget carriers by December.

China Eastern chose China United and the Beijing base for its first low-cost airline because it is in the only one of three main metropolitan agglomerations not subject to budget competition, says China United Chairman Tang Bing, who is also deputy general manager of China Eastern. The others are

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# Deadly Delay



Slow action on collision-warning systems cost lives, says U.K. Military Aviation Authority

**Tony Osborne London**

**T**he U.K.'s fleet of Tornado fighter bombers is being fitted with an airborne collision-warning system (CWS)—but only five years before they go out of service. Flight tests of the new system are being conducted by BAE Systems, and the Defense Ministry intends to retrofit the whole fleet by year-end. But military flight safety officials say that missed opportunities to equip the aircraft with the system earlier have cost lives.

In its report about the latest collision—of two Royal Air Force (RAF) Tornado GR4s off Scotland in July 2012—the U.K.'s military air safety body, the Military Aviation Authority (MAA), criticizes the Defense Ministry for consistently deferring, reprogramming and reprioritizing the introduction of a CWS for the aircraft. The MAA is calling on the ministry to ensure that the Eurofighter Typhoon and F-35 Lightning II are equipped with a CWS, “neither of which has a requirement or program” for the fitment of such a system, it notes.

Three RAF airmen died when the two Tornado GR4s, being flown on separate training missions in Northern Scotland, collided 900 ft. over the Moray Firth 7 mi. east of the village of Helmsdale on July 3, 2012. One airman managed to eject but has been unable to recall the accident, which was described by the MAA in its June 30 report as a “high-energy collision over the sea” that produced a “complex” and “highly destructive accident sequence.”

Callsign Aston 1 (aircraft ZD743) had been completing a low-level mission in the north of Scotland, while Abbot 2 (aircraft ZD812) had been flying a gunnery training mission over the nearby RAF Tain air weapons range when the two aircraft collided at midday. Investigators say the leading edge of Abbot 2's right wing collided with Aston 1's front fuselage and cockpit.

One-third of Abbot 2's right wing and the rear cockpit of Aston 1 broke up as the aircraft collided, and as the rear of the Aston 1 cockpit broke up, the front of it became separated from the fuselage.

Both Abbot 2 crewmembers were able to eject, but only the pilot in the rear seat survived. The Aston 1 weapons

systems officer in the rear seat was killed immediately by the collision; his pilot did not initiate an ejection.

Investigators say the two crews' lack of situational awareness of one another's sortie from the mission planning phase right through to

**The deferred installation of a collision-warning system contributed to the loss of this and another Tornado in a mid-air crash in July 2012, says the U.K. Military Aviation Authority.**

the actual collision was “highly significant.” “Unfortunately the final safety barrier that would have generated aware-

ness of their close proximity did not exist, as the Tornado is not fitted with a Collision Warning System,” the report states.

While the lack of a CWS on the Tornado did not cause the accident, it is identified as one of 17 contributory factors that made it more likely to happen.

The report points out that there were 42 mid-air collision events involving RAF aircraft in 1979-2001 resulting in the loss of 40 lives and destruction of 47 aircraft, including 12 Tornado GR1s and GR4s. Since 2001, there have been nine more mid-air collisions involving U.K. military aircraft that killed 17 more airmen, including three air cadets.

The introduction of a Tornado CWS has its roots in the 1998 Strategic Defense Review but has suffered from numerous delays, cancellations and deferments, without a coherent audit trail, making it difficult “to gain a complete picture of the decision making” the MAA states. “Over the next 14 years [after 1998], the [Tornado CWS] program was subject to five deferrals, reprogramming prioritization, deletion in 2010 and eventual resurrection in 2012,” MAA officials say.

A CWS for the Tornado could have been put into service by 2010, and “should have been fitted at the time of [the July 2012] Tornado accident,” the report adds.

The program to add a CWS, initiated four months after the July 2012 collision, will use an off-the-shelf system fitted into the front cockpit of the Tornado. Flight trials for the £53 million (\$87 million) project began during the spring of this year, and the RAF hopes the system will be in service in December.

The risk of mid-air collision is seen as the highest operating risk by MAA air safety officers. In addition to the Tornado CWS program, helicopters are being equipped with warning systems as well. But in the MAA annual report published in April, Director General Air Marshal Richard Garwood notes that as unmanned air vehicle flights become more prevalent and military flying levels increase with the return of U.K. forces from Afghanistan, the potential of collisions is “likely to remain a strategic risk for some time.”

CWS are not a panacea, officials warn, since many general aviation aircraft are not fitted with Mode-S transponders, which talk to the CWS to prompt an avoidance maneuver. ☛

**PARTS**

## Parts-Buying Essentials

The battle between OEMs and  
independent suppliers to meet  
shifting operator needs

*MRO4*



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The next issue of the MRO Edition will be dated Sept. 8.

## A Maturing MRO Market

**T**he hangar-services-only days in Central and Eastern Europe are over—as is “hangar mania,” which is how former FL Technics CEO Jonas Butautis described the proliferation of basic MRO services that popped up there over the past few years and created overcapacity.

MROs in the region have been trying to grow their businesses through niche offerings, such as winglet installations, which don't require huge investments.

Aeroplex of Central Europe in Budapest restarted its aircraft disassembly and recycling activities, as well as opened a line maintenance and aircraft storage facility at Heviz-Balaton airport in Sarmellek, Hungary, to take advantage of the bustling surplus material market.

Adria Tehnika, which spun off from Adria Airways as an independent MRO a couple years ago, is investing in workshops to diversify its airframe business. Mirjana Tratnjek Ceh, deputy CEO of the MRO based in Slovenia, credits becoming a Bombardier service center a decade ago with helping kick off its third-party business. Adria Airways represents only 30% of Adria Tehnika's business, compared to competitors in the region, which still get about 60% of their MRO business from an affiliated airline, according to Ceh.

And while this region still has a labor cost advantage over Western Europe, it faces hypercompetition from other area MROs, as well as Turkey.

The majority of MROs in the Baltics and Eastern Europe also face the challenge of working with an old infrastructure from former government facilities—and some are still tied to legacy airlines that are unprofitable.

In addition, some MRO leaders whom I spoke with at our MRO Baltics, Eastern Europe and Russia (BEER) Conference in Warsaw in June are having a hard time getting operators with financial troubles to pay bills. On top of this, airlines and MROs in this region are being squeezed by major European airlines as well as ultra-low-cost carriers,



**“The permanent pressure on costs and continuous improvement processes didn't exist as it does today”**

ers, which forces the MROs to move beyond just cost-cutting measures to new efficiency and process improvements.

Customer assistance and faster and more innovative service options must be adapted. This is what LOT Aircraft Maintenance Services (AMS) is doing. Before becoming independent, “the permanent pressure on costs and continuous improvement processes didn't exist like it does today,” AMS board member Pawel Gontarczyk said at the conference. The MRO is using maintenance planning—including inventory optimization—to improve operating efficiency, trim turnarounds and cut costs. This includes a restructuring aimed at better using its people and facilities in Warsaw and creating new revenue streams through activities like line maintenance, which delivered 29% of its 2013 revenue (AW&ST June 30, p. 22).

While walking through its hangars in Warsaw, it's palpable that LOT AMS strongly desires to emerge from the restructuring and add capabilities such as A320 and Boeing 787 base maintenance. Although a small World War II guard station still stands alongside a ramp, reminding you of what this country underwent during the war and the Warsaw Uprising, it's more a symbol of surviving and moving beyond—not about the past. ☺

—Lee Ann Tegtmeier  
Chief Editor MRO

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# Greater Expectations

Independents, OEMs grapple to meet operators' spare parts demands

Sean Broderick **Washington**

**T**he spare parts business, once a mundanely straightforward enterprise of new material flowing from manufacturers to operators, has evolved into one of commercial aviation's most dynamic—and paradoxical—sectors.

Incorporation of cost-saving used parts is on the rise, yet the leading consumers of them are original equipment manufacturers (OEM). Some image-conscious airlines embrace used material but draw the line at taking components refurbished by indepen-

dent shops, insisting instead on parts repaired by the OEMs that made them. And despite projections that show the global airline fleet doubling by 2033, many aftermarket suppliers are focused just as much on diversification and consolidation as on growth.

OEMs and MRO providers like AFI KLM E&M are both competing and teaming up to meet demand for better and cheaper services.

Each of these seemingly complex trends is explained by a simple and enduring precept: Cost-conscious operators are driving innovation throughout the aftermarket supply chain, urging everyone in it—from the largest OEMs to the dedicated used-parts broker—to deliver more value.

For many operators, value means flexibility.

When Moog set out to develop its aftermarket support for the flight controls it exclusively supplies for the Boeing 787 and Airbus A350 programs, the company sketched out a straightforward power-by-the-hour (PBH) offering. One of the main goals was tighter alignment with customers, explains Kate Schaefer, Moog's general manager-Commercial Aircraft.

In the past, Moog found that reliability data on its products was hard to gather, in part because so many different shops were overhauling its components. A PBH deal would shift cost-containment risk to Moog, incentivizing it to maximize reliability and, by putting itself in the repair pipeline, providing the insight needed to measure its progress.

As Schaefer and her colleagues visited 787 operators and outlined Moog's plans, they quickly learned they needed a broader set of services. Some airlines said they prefer to buy spares, for instance, and some want to lease them. Moog also found that its forward-stocking program—set up both to offset customers' dedicated inventory needs and to tackle emergencies such as an aircraft-on-ground (AOG) scenario—appealed to a much broader set of customers than expected.

"We always thought it was the smaller airlines that were looking for this, but that is definitely changing," she says. "Even larger, more traditional airlines are using a forward-stocking option to top up" their dedicated spares pools.

Moog developed options to cover the variety that airlines asked for, from basic time-and-materials repair service to PBH. It also sought deals with more comprehensive maintenance providers, such as Lufthansa Technik, to satisfy operators that prioritize a streamlined supply chain.

"We set about coming up with options for all of those airlines," she explains. "But we also understood clearly that there are airlines that have a buy-



PATRICK DELAPIERRE/AIR FRANCE INDUSTRIES/KLM

ing behavior that we can't support—the ones that want nose-to-tail support.”

Moog's new aftermarket program—specifically, the forward-stocking initiative—presented a non-traditional opportunity for growing supplier Aero-Turbine. Moog set up spares centers in Beijing, Dubai, London, Los Angeles, Melbourne, Miami, Singapore, and Sydney, and needed an experienced logistics provider to keep parts moving. A parts supplier at heart, Aero-Turbine offered Moog elements that traditional logistics providers cannot. Chief among them: firsthand understanding of what Moog's customers face when a part is needed.

“I know what an AOG is,” says Josh Abelson, AeroTurbine's senior vice president-Supply Chain Solutions. “We can speak their language.”

AeroTurbine's evolution underscores the types of shifts that many suppliers are making to meet customer demand. Launched as a used engine parts supplier in 1997, the Florida-based company now provides services ranging from boutique airframe maintenance—it runs four heavy check lines for Frontier Airlines A319s and A320s at its Good-year, Arizona, repair station—to technical assistance on lease returns. Forced to start buying entire aircraft just to get the engine material it wanted—a move that prompted an expansion into airframe parts—the company soon developed a short-term lease business. This allows AeroTurbine to buy engines and aircraft, place them with operators on short-term deals to run off green time, and then part them out.

While other parts suppliers and even independent MRO providers have lease pools that feed used parts stocks, few have a direct pipeline into a fleet of 1,300 aircraft. AeroTurbine's 2011 purchase by International Lease Finance Corp.—now part of AerCap—means the parts specialist has a dedicated feed of aircraft transitioning between operators and, eventually, out of the fleet. AeroTurbine tears down up to 30 aircraft per year, sourcing 30% of them from its parent. This helps ensure Aero-Turbine, which generates about 60% of its \$500 million in annual revenue from parts, a steady and predictable component supply. The latter is key to providing services like pooling and the Frontier work, which require having specific material at the right time.

## Airbus A320 and Boeing 737 Shares in Global Fleet

|      | Aircraft Installed Base |     | Aircraft Deliveries |     | Aircraft Retirements |     | MRO Spending |     |
|------|-------------------------|-----|---------------------|-----|----------------------|-----|--------------|-----|
|      | A320                    | 737 | A320                | 737 | A320                 | 737 | A320         | 737 |
| 2014 | 20%                     | 22% | 31%                 | 28% | 11%                  | 14% | 18%          | 17% |
| 2015 | 21                      | 23  | 31                  | 27  | 6                    | 14  | 19           | 17  |
| 2016 | 22                      | 23  | 29                  | 27  | 8                    | 10  | 20           | 17  |
| 2017 | 23                      | 24  | 30                  | 27  | 7                    | 14  | 21           | 19  |
| 2018 | 24                      | 24  | 27                  | 29  | 5                    | 14  | 23           | 19  |
| 2019 | 24                      | 25  | 29                  | 28  | 7                    | 16  | 24           | 19  |
| 2020 | 25                      | 25  | 28                  | 28  | 10                   | 16  | 24           | 19  |
| 2021 | 25                      | 25  | 28                  | 29  | 13                   | 16  | 24           | 20  |
| 2022 | 26                      | 26  | 28                  | 30  | 14                   | 23  | 25           | 20  |
| 2023 | 26                      | 26  | 28                  | 30  | 14                   | 31  | 25           | 21  |

A320 family is A318, A318CJ, A319, A319CJ, A319neo, A320, A320CJ, A320neo, A321, A321CJ and A321neo. 737 family is 737BBJ, 737 MAX, 737-200, -300, -400, -500, -600, -700, -800 and -900.

Source: Aviation Week Fleet and MRO Forecast 2014-2023

“The parts business is going to become commoditized,” Abelson says. “The traditional surplus parts market will be under pressure. We need to evolve our services business.”

The demand for used parts may wane as inventories are stocked and new-generation equipment like the 737 MAX and A320neo displace today's workhorses, or if a spike in fuel prices renders older, less-efficient aircraft too expensive to operate. For now, however, operators' thirst for used serviceable material (USM) remains seemingly unquenchable. ICF International sees the USM market rising at a 5.5% compound annual growth rate through 2022, climbing from \$3.5 billion in 2013 to \$6.2 billion in a decade, excluding transactions between dealers. Richard Brown, an ICF analyst, calls this the “medium growth” scenario. Its assumptions include a slight uptick in interest rates, a slight dip in fuel prices, run-of-the-mill delays in new aircraft programs (the 787 program delays gave some older widebodies new life) and no major disruptive tactics from original equipment manufacturers.

Repairs and used parts demand are driving strategic shifts throughout the supply chain. USM suppliers increasingly are branching out into related areas like parting out and repairs, or finding partners that provide such services. This pleases airlines, many of which are looking for stronger partnerships, more cost-savings opportunities and in some cases, fewer purchase orders.

Republic Airways Holdings contracts out 80% of the maintenance for its Chautauqua Airlines, Republic Airlines and Shuttle America subsidiaries. The airline monitors myriad

data points that help it identify factors such as parts consumption and other cost drivers throughout its fleet, says Andrew Skaff, vice president-Supply Chain. It shares the information, as well as the company's big-picture goals—including a cost-per-available seat-mile of 8.85 cents or less and a 99.1% controllable completion factor—with suppliers. They are expected to use the data to improve key drivers like their forecasting, and by extension, their services.

“I think it's very important from a supplier perspective that you are aligned with the customers you support,” Skaff says. “If there is a [part] stock-out on a situation that created an AOG at the airline, did you support the completion factor or inhibit it?”

Shifting airline strategies have OEMs re-shaping their service approaches as well. The USM trend is one example, particularly on the engine side, where material costs account for 70% of a shop visit. General Electric, which has 33,000 engines in airline service (counting models from joint ventures CFM and Engine Alliance), generates an industry-leading \$7.9 billion annually from its services business. It also sells more USM—about \$700 million per year, or one-third of a \$2.2 billion annual used engine parts market—than anybody else.

Most of these parts go into GE's own shops, supporting customers it has under contract. GE does not disclose the number of engines under long-term deals, but consultancy TeamSAI estimates the percentage ranges from 40% on the current-generation CFM56s to 60% for the GE90 and as high as 80% for yet-to-enter-service Leap. Counting these contracts and factoring in

joint venture revenues, GE's services backlog is \$96 billion. Much of it—\$43 billion—is for CFM engines, while the GE90 accounts for \$27 billion, and the GENx, \$13 billion.

Such figures spotlight cost-savings opportunities stemming from incorporating used parts. GE has in recent years revamped its support offerings, incorporating more USM into overhauls where it makes sense, says Nathan Hoening, general manager and business leader of GE's Aviation Materials business. In some cases, the goal is meeting a specified build standard designed to minimize overhaul costs on an engine headed for retirement. In others, it is about leveraging USM to get the most out of dollars spent throughout an

which overhauls the engine type in its Helsinki shop.

Independent suppliers also turn to OEMs to return their harvested parts to airworthy condition. While the repairs pipeline also includes independent MRO shops, some airlines like the combination of a used part with an OEM repair tag, while repair shops can use them as differentiators.

Airframe and component OEMs dabble less in the USM market than their engine counterparts. This is partly due to demand, as 62% of the \$3.5 billion annual USM market is for engine parts, ICF calculates, while most of the rest is for components and just a sliver—less than 5%—is for airframe material.

Market dynamics also play a role.

the expansion also boosted its ties with OEMs, which—as Moog does with AeroTurbine—recognize the strengths that independent, service-focused businesses can provide as partners.

"The two complement each other," Simmonds says of OEMs and his group. "AJW has a route to market and tailored solutions. OEMs have the intellectual property and software rights."

Joe Dunne, Boeing's director of Material Management Services, agrees with the general premise. Boeing, which puts itself as the number three commercial aftermarket services provider by revenue after GE and Lufthansa Technik, has made bolstering its commercial services business a priority.

"Does that mean we have to do everything ourselves? Not necessarily," Dunne says. "We have no desire to control the market. We have a strong desire

### **Republic shares its key metrics with suppliers and expects their help in hitting the targets.**

to participate in the market. If there are things within the services required by our customers that are better done by somebody else, then we will entertain relationships with those providers." One example is Boeing's 777 component service program with Air France Industries KLM Engineering & Maintenance—a deal that started in 2003 and was renewed earlier this year. It serves 18 airlines and 177 aircraft.

Dunne, speaking to airline maintenance executives at April's Aviation Week MRO Americas event in Phoenix, was adamant about one aspect of the aftermarket: Nobody has better tools to keep a fleet stocked with the right spares at the right time than the airframe manufacturers. From reliability data to a global network of engineers and parts warehouses, the airframe OEMs are ideally positioned to take advantage of operators' desire to have spares at arm's length—but not in their own stock bins.

"When you think about investing in a pool of inventory, it has to be dynamic," Dunne says. "The market says, 'I want [to ensure] that material [availability] never becomes a driving disruption to my fleet.' The OEM, given its size, its knowledge, and its infrastructure, is in the best position to do that." ☛



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engine's lifecycle—an approach that GE has increasingly embraced as more of its engines reach maturity and customers seek more creative options.

"We've changed in terms of how we approach the market from a mature fleet standpoint," Hoening says. "We've done a lot of work internally that has increased the amount of surplus material that we've provided through our own contracts and into our own overhaul shops."

While the OEM shift into USM markets rattles many an independent supplier's nerves, it also creates opportunities. GE and its competitors source many of their parts via teardowns, but also acquire a fair amount on the open market. They also make USM available to other end-users.

"Some of these third-party parts suppliers stretch out into other areas, such as overhaul shops," Hoening notes. "In a lot of cases we can become a supplier to them."

One example is GE's deal to supply used CF6-80C2 parts to GA Telesis,

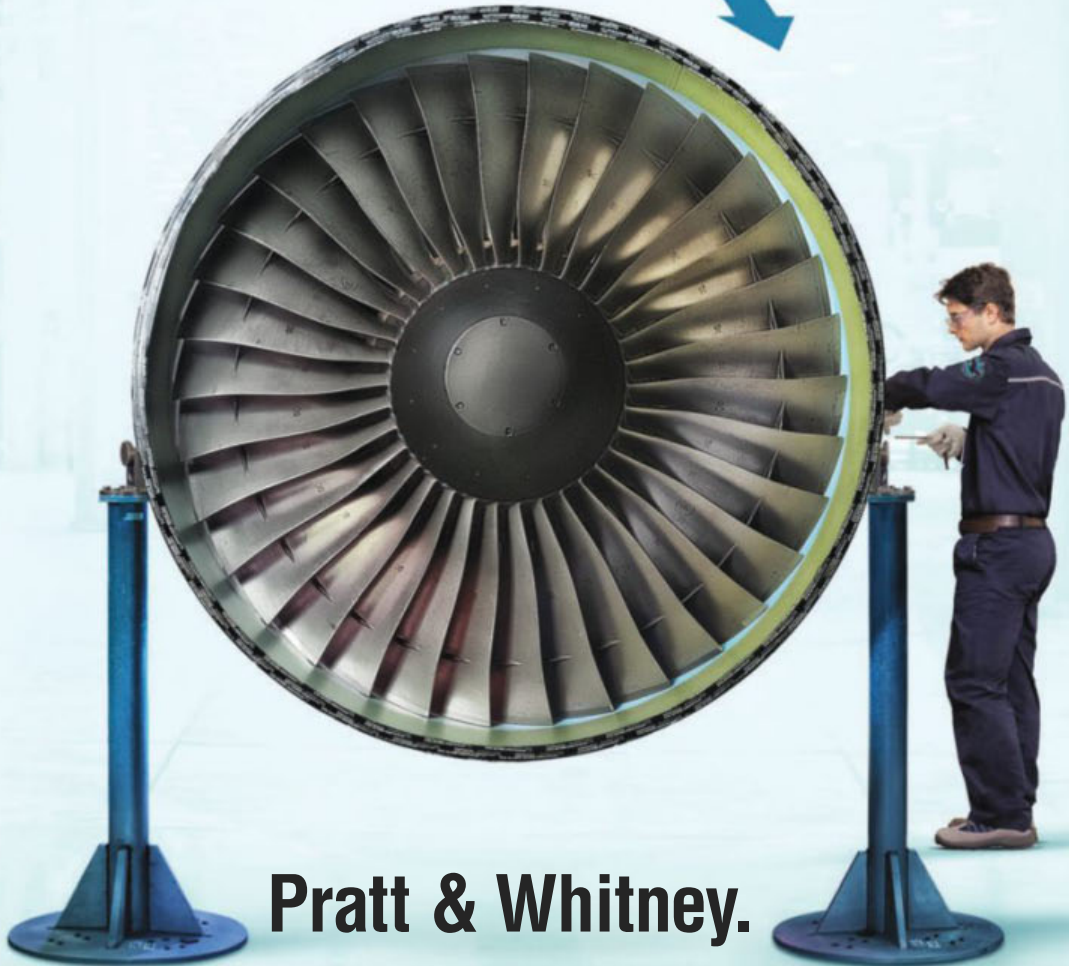
"We have a good understanding of fair market value because we trade parts every day and our business model is predicated on customer service and logistics," AJW Aviation CEO Boris Wolstenholme explains.

Add in that even the most savvy OEMs must focus first on new products—and even then only for the aircraft or engine programs they are involved in—and large independent suppliers can leverage their day-to-day experience to gain the upper hand.

"AJW provides [product type] integration seamlessly, utilizing a mixture of tear-down aircraft, large tailored inventories, and OEM support programs," says Gavin Simmonds, general manager of AJW Technique, the group's Montreal-based component service center.

Technique, formed when AJW Group bought the component business of the insolvent Aveos and opened last year, broadened the group's offerings and gave it a significant presence in North America. Simmonds contends

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# Demand Forecasting

## How to get the right parts at the right time to the right place

Henry Canada Washington

Under competitive pressure, airlines are moving away from holding huge (and hugely expensive) parts stocks to support operations. But they still seek the extremely reliable dispatch these stocks supported.

The new approach requires getting the right parts to the right place at the right time, and it is tricky. It requires sufficient scale, sophisticated forecast-

spares and repairs. Mean time between removals (MTBR) influences spares only. Fleet size, transport cost and time, internal or external repair time and repair cost also go into the calculation. Reliability reports are used for MTBF and MTBR.

Trax forecasts part requirements for airframes and components, but not engines.

Not all customers use all Trax part-

Airlines has used Maintainix to eliminate delays caused by lack of materials and to reduce gross part stocks by 10%.

While airlines have good forecasting tools, most lack the scale to forecast unscheduled part requirements precisely. And airlines often have limited stocking choices and logistics expertise. Enter the parts-management specialist.

John Avery, director of Supply Chain Solutions at AJW Aviation, says his company's flight-hour programs aim at very specific key performance indicators (KPI) such as target costs, technical dispatch reliability and material cost per flight-hour or cycle.

Long-term, special packages usually support engines and landing gear. Of the rest, 80-90% of cost is for rotatables, the remainder for consumables.

The key to controlling consumable costs is "managing the complexity of many parts costing small dollars each," he explains. Often complexity is handled by highly specialized distributors who

**Part demand is integrated to planned and forecasted work packages in this example. The aggregate of all the part demands for planned and forecasted checks is used to create the forecast.**

work with just a few—say 200—part numbers that they can deliver rapidly.

AJW handles consumable complexity differently. Via the consignment option, it delivers parts to airlines, monitors use and replenishes when stocks hit the reorder point. The company can buy cheaply in volume and ship economically also, as it is usually shipping components to the airline several times a week and just adds in piece parts. The airline gets parts without minimum orders, and its in-house engineers concentrate on modification work and other tasks that outsiders cannot do.

The MRO provider knows when to replenish rotatable stocks because it makes usage forecasts based on nearly 500 aircraft under flight-hour contracts for rotatables. The law of large numbers reduces variation in requirements. "If you need \$5 million in rotatables for one aircraft, you need \$8 million for two," Avery explains. Scale economies continue up to about 200 aircraft. AJW can help even much larger fleets—for example, U.S. majors when they fly to Europe, far from their base stocks.

The screenshot shows the 'Work Package Details' for 'WP-T005CGJA [T005CGJA]'. It includes a table with columns for Line, Name, ID, Status, Sched. Start, Qty, Description, Assembly Position, Position, Note, Request ID, Priority, Status, ETA, Part Provider, and Available Qty. The table lists various tasks and their associated part requirements, including items like 'DISCARD LAVATORY AIR EXTRACTION FILTER ELEMENT', 'FUEL-3000-03080 (MANTA FILTRANTE VILLODIN)', and 'DISCARD LAVATORY AIR EXTRACTION FILTER ELEMENT'.

ing, well-placed stocks and smart logistics. Airlines can perform some of these tasks, but OEMs and other companies are responsible for an increasing share.

Airline MRO software Trax forecasts both consumables and rotatables. Task orders from OEMs tell Trax and airline users which scheduled consumables are needed, explains Managing Director Chris Reed.

Trax uses historical data to forecast demand for unscheduled consumables. Users set the amount of time a needed part must be available. Trax optimization routines then use costs and criticality to set reorder points. Trax also calculates the economic order quantity (EOQ) that minimizes inventory and ordering costs according to the Wilson Formula, one of the oldest production scheduling models.

Trax sets the inventory of rotatables based on several factors. Mean time between failures (MTBF) influences

forecasting capabilities. Small airlines may only want EOQ. Larger airlines set up and manage optimization algorithms. If a carrier is on a flight-hour program with a provider, Trax routines can be turned off by ATA Chapter or by part number.

Mxi's Maintainix forecasts are similar to those of Trax, with several important differences. Product Marketing Manager James Elliott says planned rotatable and consumable requirements are based on flight hours, landings and other parameters. Reliability reports help forecast unplanned parts needs.

But Maintainix also forecasts engine-part requirements, based on tools developed with the U.S. Navy, where overhaul time was halved by ensuring parts were ready. And Maintainix's configuration management ensures that scheduled parts exactly suit aircraft by tail number, not just model or variant.

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Scale also justifies AJW's large technical department, which gets better with experience at managing repairs and arranging warranty coverage. And scale pays for AJW's highly sophisticated part-forecasting system.

AJW recommends airlines lease their main base kits so they retain flexibility to re-fleet with other models or variants. The company can reposition leased stocks where needed.

Making it all work starts with forecasting and IT. "If you don't have a good information system, you will be dead in 90 days," Avery stresses. "You will lose track of stuff." In addition,

months. AJW also helps get technical dispatch reliability up, although this KPI depends on other factors.

Parts traders are also active. Avtrade has developed an in-house, web-based interface that provides real-time ordering, availability and documentation to customers, explains Regional Marketing Director Toby Winkworth. Customers also benefit from Avtrade's experience in forecasting removal rates.

Avtrade stocks are kept at a new logistics center in the U.K. and hubs in the U.S., UAE and Singapore. The company has relationships with most global freight providers, including spe-

as the OEM guarantees airlines always will have needed parts on site. Forecasts are based on usage for older equipment and on engineering data for new components. Rockwell must predict MTBR and MTBF separately due to no fault founds. The company can help airlines forecast requirements even if they are not using integrated solutions.

Gains from relying on integrated solutions vary by carrier, and Tosi does not see airline spreadsheets. But he notes that airlines—including some very large ones—are shifting to this support model, so benefits must be attractive. A Rockwell subsidiary now buys aircraft for tear-down, and the company has committed to flexible support at affordable pricing.

Engine makers started the flight-hour approach and pursue it aggressively. Pratt & Whitney certainly has the necessary scale, with 11,000

### **Rockwell Collins forecasts parts requirements for both transactions and integrated contracts.**

engines operating. Forty percent of PW4000s are under flight-hour support, as are 60% of V2500s. Ajay Agrawal, vice president of commercial aftermarket, expects 80% of GTFs to be similarly covered.

Pratt stocks 20,000 new part numbers and 25,000 numbers of surplus parts. It commits to fulfilling orders promptly 95% of the time and is hitting 97% currently.

"Forecasting is the backbone," Agrawal stresses. Pratt uses SAP forecasting and planning tools (see related story, MRO22), plus in-house applications and a team of PhDs to constantly refine forecast algorithms. These are based on shop visits, work scopes, historical demand and data on engine operation, especially from flight-hour customers. Forecasts are 98% accurate, and Pratt is investing in Big Data tools to improve them further.

New parts are held in the Netherlands and at Atlanta Hartsfield Airport, surplus parts in Dallas. Only airlines that overhaul their own engines have much in the way of on-site inventory.

UPS provides logistics at all stocking locations, running warehouses in partnership with Pratt staff, and managing transportation. Most parts are shipped in three days, but life-limited parts can take up to a month. ☛



ROCKWELL COLLINS

AJW does three things very well: customer service, logistics and holding a large inventory.

Logistics ensures the right parts are in the right amounts at each warehouse after a receiving inspection and are put on the shelf and row where they belong. Then parts are packed correctly with the right paperwork, photographed to show condition, shipped by the best option, and finally tracked step-by-step.

AJW staffs its own warehouse, but contracts out transport, mostly to DHL, FedEx and B&H Worldwide. When a van leaves an AJW warehouse, another has to be there in 15 min. Customers have complete visibility into shipments, including cellphone numbers of drivers in transit.

The results can be measured. Avery says AJW flight-hour support can cut direct costs for fleets of 10-15 aircraft by 20-25%. These costs will be predictable and lower in winter, when revenue is down, higher in the active summer

specialists in engines, AOG situations and hazardous materials.

OEMs increasingly manage part supplies for their products. For example, Rockwell Collins is seeing a steady trend from transaction-based support toward more integrated solutions, including its Total Dispatch Reliability program, says Thierry Tosi, vice president of service solutions. He predicts 70% of Rockwell support will be integrated in 10 years. Half of Boeing 787 support already is.

Rockwell must invest in parts pools before they reach self-sustaining size. Some customers want local pools and to tap global stocks for replenishment. Global stocks are now kept in three centers at or near hubs in America, Europe and Asia. A Middle East warehouse may be added in the future.

Rockwell forecasts parts requirements for both transactions and integrated contracts, but the forecast is more important for integrated deals,



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# CFM56

# Organic MRO

Southeast Asian MROs are using collaborative ventures to maintain quality while they grow

Jeremy Torr **Singapore**



**L**ook at any current MRO industry analysis, and the compass swings predominantly east. Asia as a whole accounted for \$14.2 billion (27%) of total global MRO spending in 2012. That's a significant amount, but one predicted to grow by 4.3% up to 2020, some 10% faster than the global rate, according to David Stewart, ICF International's regional head of aviation and aerospace. As Stewart notes, it's a market that has made both Boeing and Airbus become "suddenly interested" in regional MRO operations.

It's not just the airframers that are taking notice in Asia. Swiss-based SR Technics set up a new component facility at Subang in Malaysia last March. Garuda Indonesia's GMF subsidiary is currently establishing a new facility on Bintan, an Indonesian island next to Singapore. Jet Aviation opened a custom-built 54,000-sq.-ft. hangar at Singapore's Seletar Airport in May. Lion Air is expanding its MRO footprint on Batam, another Indonesian island in close proximity to Singapore—but with a 13,000-ft. runway. And Lufthansa Technik Philippines has just added its second A380 customer, Air France.

Indeed, many airlines from Europe, America, the Middle East and Africa are looking for competitive airframe

maintenance services—and are seeing Asia as the best option. The lower wage costs, well-educated technical workforce and rapid expansion of local airlines all indicate good future MRO prospects, especially for narrowbody and regional aircraft.

But as Jemsly Hutabarat, vice president-marketing & sales at GMF Aeroasia notes, two issues offer potential hurdles. "These are trained manpower and capital-intensive high-tech issues," he says. "Both offer particular challenges in the region." Having plenty of relatively cheap workers is good—as long as they are trained and certified. And investing in high-tech equipment is essential—as long as customer volumes justify the expense.

One way around both these issues is to work not in competition with other local operators but in concert with them, at least until the local MRO market has expanded

**SR Technics is opening a new component facility at Subang, with a projected 240 workers.**

enough to support a highly segmented and organized market such as those in the U.S. and Europe, says Gary Dolski, Jet Aviation's vice president-Asia Pacific. "We try to do all our own work," says Dolski, "but would certainly flag opportunities to other operators if the need arises, or if we couldn't handle a specialist function." As Dolski explains, this is not always on an official basis through a contracted joint venture, but can instead be on a shared working relationship basis, between nearby MROs that each have unique facilities.

**Garuda Indonesia's GMF subsidiary is establishing a new facility on Bintan, an Indonesian island next to Singapore.**

"For example we use Hawker Pacific's paint shop [in an adjoining hangar at Seletar] for some specialized work, and they use us for projects that they cannot handle on their lines, like interiors," he says. Dolski maintains that rather than being classified as a joint venture, he would rather describe it as a "smart working relationship."

This kind of growth—using a more organic approach rather than specialized and targeted investments—is something SR Technics also supports according to Felix Ammann, senior vice president of component services.

Ammann says the company has established its new component facility at Subang, with a projected 240 workers servicing 1,200 components in a year's time, and is preparing for the next stage of growth. "We must have global and regional partnerships. We are always looking at [our] heavy maintenance offerings, and will possibly expand—or look at other options," he says.



SR TECHNICS

Like GMF, SR Technics is finding that the relatively undeveloped market means there are a few stumbling blocks to deal with in collaborations. One issue in the region is the ability of technicians to speak and read good English—all aviation manuals and references require that as a basic skill, says Heinz Freimann, general manager at the SR Technics Subang facility.

This emphasis on strategic partnerships is just one of the strategies that GMF is pushing in the pursuit of QCDS (quality, cost, delivery, and services), says Hutabarat. This approach is becoming increasingly important as the rapidly expanding ranks of Southeast Asian LCCs look for one-stop MRO capacity—and the choice of partner is not restricted to players within the MRO industry, he says.

Today's MRO operator is also looking at collaborating with airlines, OEMs, financial institutions, and even airport operators and owners as potential partners in new ventures.

This approach also helps reduce "employee churn" in which the highly skilled will be tempted to move from employer to employer in pursuit of wage hikes, resulting in labor shortages and a lack of capacity.

More joint and cooperative ventures also will help the fledgling Asian MRO industry avoid becoming locked into a downward cost spiral that simply emphasizes low labor costs rather than high competence: an approach that is fine for airframe work but is unlikely to attract engine or avionics business, which demand specialist skills and technology investment in order to offer a good value proposition.

The unique demands of the region require a higher-than-usual degree of competence at other levels, too. One Singapore MRO provider complains of having to be certified for 10 different national aviation bodies in order to perform MRO work for its portfolio of regional customers—and the demand for unique national sign-offs instead of comprehensive FAA or EASA certification is increasing all the time.

Nonetheless, the local MRO operators must start somewhere. From a relatively small base, they are initially offering what Hutabarat calls the "low-hanging fruit," including sectors such as airframe maintenance, then moving on to more capital-intensive and high-

tech products such as component overhaul, cabin, and engine maintenance. This definitely poses challenges, but as Jet Aviation's Dolski notes, regional growth of aircraft coming through the region is good, "... and we are planning for the long-term," he says.

The main challenge for the region is to concentrate on producing comprehensive quality—and likely multi-

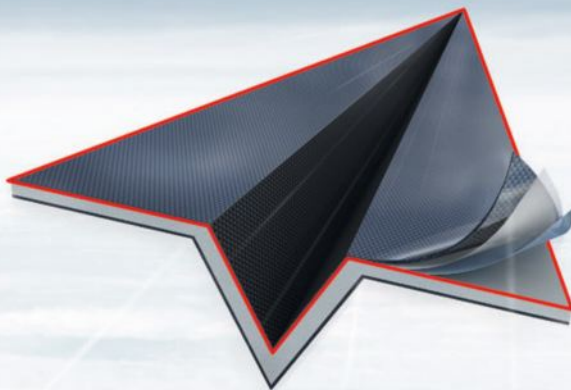
vendor-provided—one-stop solutions.

But unless the industry works together and pools expertise and capabilities, there is a danger Asia could simply be seen as a cheaper (and lower-reputation) option, warns Hutabarat. "If Asia is seen to have weakness in quality, then customers will start looking for another source, such as South America," he says. ✖

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# Private Influence

Private investors continue to weigh in and affect industry outcomes

**Michael Bruno** *Washington*

**F**rom aircraft lifespans and parts inventories to corporate valuations, private equity continues to alter the aviation industry and the maintenance, repair and overhaul (MRO) sector.

Bottled up by the Great Recession and the slow, subsequent economic recovery, private investors could be becoming more active. Evidence remains anecdotal, but they are being cited by industry observers for both overt and indirect influences.

Recently, for example, aircraft aftermarket provider Wencor Group unveiled its purchase by private equity firm Warburg Pincus. Rumored for weeks in news articles, Warburg and current Wencor owner Odyssey

Investment Partners unveiled the deal May 21 Terms were not disclosed.

The transaction should close this quarter, they said. All three parties praised Wencor's growth potential as underpinning the deal.

Wencor CEO Greg Beason said Odyssey left Wencor "well-positioned" to add to its existing offerings. "We are excited to have Warburg Pincus as our partner for the next chapter in the company's growth, given their deep aerospace investing experience and focus on supporting growing businesses."

Dan Zamlong, a Warburg managing director agreed and said, "There is significant opportunity to build on Wencor's success by developing new product and repair offerings. Wencor offers

airline and MRO customers a compelling source for aftermarket components and repairs and we look forward to working with the management team to pursue organic and acquisition growth initiatives."

Indeed, aircraft parts companies are experiencing a run-up in M&A activity, fueled in part by private equity's desire to claim a stake in the commercial aviation growth being forecast worldwide, according to Michael Richter, head of the aerospace and defense investment banking group at Lazard. While private investors' bids can lead to higher M&A-related costs for industry buyers like Precision Castparts—which has been on an acquisition spree, advised in part by Lazard—the growing interest of private investors also confirms the strength of the market and forecasted demand, he told Aviation Week.

Elsewhere, the surge of private investment is having more inadvertent—albeit tangible—effects. For instance, the useful life of a commercial aircraft is increasingly tied to two variables: who owns it and what type it is.

Aircraft can fly for 25-30 years, but as lessors become a bigger segment in the ownership market—from 40% to possibly 50% in coming years, driven in part by growing ranks of private investors—the shift can make all the difference for some mid-life aircraft.

Airline owners may see value in overhauling an aircraft and upgrading elements like cabin interiors. But lessors see money to be made in cannibalizing and selling parts versus spending on mid-life MRO. Aircastle CFO Mike Inglese explained at the RBC Capital Markets investor conference in mid-May.

"By and large, it's not necessarily [airframe] life that matters," said Inglese when asked if the industry should change its view of lifespans. "It's kind of how you are thinking about that value curve along the way, and what you'll realize when it's at age 18 versus what you might have realized had you had another lease-turn and getting it deeper into its economic life," he said.

"For us it is simple economics and cash . . . and what am I going to do with that cash if I realize it today. In a number of circumstances over the course of the last year and a half, we've found that it is much better to take that cash and invest in a new asset rather than recycle an out-of-favor asset into a tough rate environment." ☛

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WHAT IT TAKES TO FLY.

# Redefining Distribution

OEMs' aftermarket pursuits making mark on even expendables distribution

Henry Canada Washington

**T**he aircraft parts aftermarket continues to transform itself as pure parts distributors feel increased pressure from the new asset-management model and some traders broaden their offers.

As OEMs seek inroads, they are squeezing distributors of even hardware and expendables, says Richard Levin, managing director of AJ Levin. Bombardier and Embraer have heavily penetrated the aftermarket arena, while Boeing's Aviall and Airbus's Satair acquisitions signal big-jet makers are following suit. "Airframers offer complete packages of spares and

in which to raise money. Hyden thinks uncertainties about regulation, health-care costs and taxes may have triggered a consolidation boom. But he says First Wave plans to stay independent, quick and competitive.

FAA guidelines for independent distributors vary across districts, which makes complying with federal regulations a more difficult task for distributors than for OEMs, Hyden explains. He believes competent distributors should be able to issue Form 8130s, just like OEMs and repair stations.

Airlines and MROs are shifting inventory costs to distributors, notes Jeff Zaslow, president of Overseas Aircraft Parts: "Distributors must make significant investments in inventory to succeed." Because most carriers operate aircraft powered by engines from different manufacturers, distributors must offer materials across multiple product lines. "Inventory is expensive, and knowing what to stock is always a challenge," Zaslow stresses. So Overseas continuously searches global markets for available inventory. "Selling good-quality material is much less difficult than finding it," Zaslow says.

Parts prices on legacy aircraft are weak, says Adrian Green of Shoreline Aerospace. "Too many people thought they could get rich tearing down older aircraft for used parts," Green suggests. "Maybe they could have five or 10 years ago, but not now." Instead, eager disassembly ventures have led to a glut of used parts on the market.

On new-generation aircraft, Green says large corporations are offering multi-year flight-hour programs. "This causes problems for pure traders and stockers." To compete, Shoreline is expanding horizontally; it has erected a hangar

**Overseas Aircraft Parts recently acquired this CFM56-5C4 to satisfy customers who operate multiple engine types and seek used material.**

for maintenance in Fort Lauderdale, Florida, and offers repair management, which it can do easily because of its South Florida location. The firm will continue to diversify.

Major asset managers say they are just meeting customer demands. Satair Group CEO Mikke Badram says his biggest challenge is juggling airlines' diverse interests. While some airlines simply seek rapid delivery on transaction-based deals, others demand integrated services ranging from flight-hour programs to vendor-managed inventory, help with inventory planning, inventory ownership and integrated material management.

Bardram says managing the increasing volume of used parts poses a major challenge, one that Bardram says prompted Satair to acquire several A340s and an A380 for teardown.

Bardram believes combining Satair with Airbus's proprietary parts division into the Satair Group was a major step in meeting demand and supply challenges. Satair's staff grew to more than 1,000 employees from 350; revenue has doubled, to top \$1 billion a year. By 2017, the company plans to be the world's largest parts manager for commercial aerospace.

Satair hopes expertise from Airbus will help alleviate customer concerns about parts taken from disassembled aircraft. But Bardram says Satair will have to make its own case on pricing to suppliers; Airbus's buying power cannot compel favorable deals there. And Satair will continue to sell parts for all commercial models because, well, that's another thing that customers and suppliers demand. ☐



OVERSEAS AIRCRAFT PARTS

services support," Levin notes. He fears Airbus will pressure suppliers to give Satair its customarily low production supply pricing, making it hard for Levin to compete.

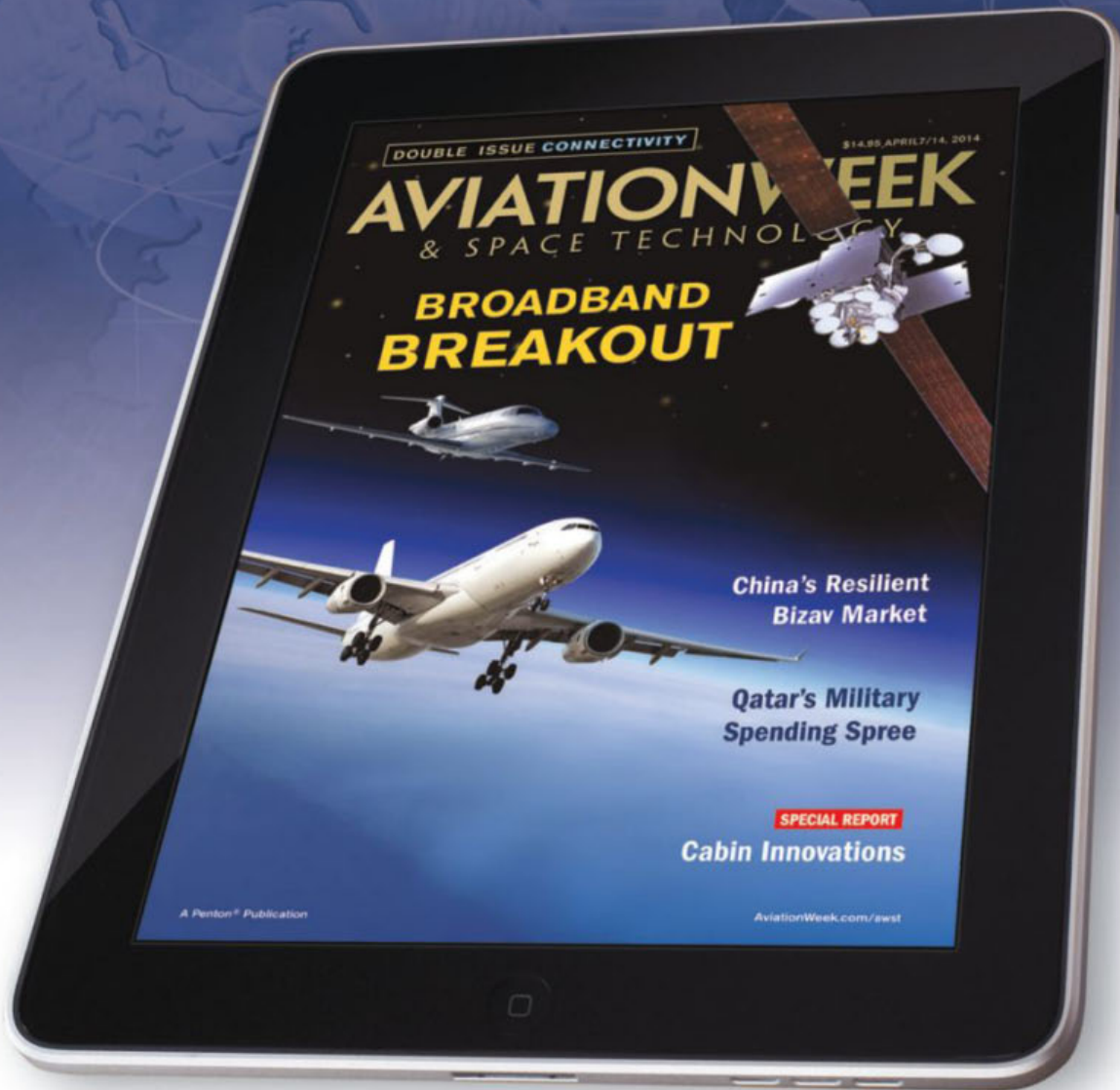
Third-party logistics providers also want to aggregate services such as rotatable and expendable management. AeroInventory tried this and went bankrupt, but Levin says stronger companies like AAR are now doing it. Air Canada is an airline that has dramatically reduced its number of suppliers. Levin says these arrangements are like vendor-managed inventory; even if his firm partners with the aggregator, it loses direct contact with customers.

Glen Hyden, vice president of First Wave Aerospace, also sees a squeeze-out from large OEMs and distributors consolidating. "One aircraft manufacturer imposed a rule last year that required buyers of their parts to deposit \$50,000, and any balance at the end of the year would be considered a royalty fee," Hyden says. "If every OEM did that, no independent distributors would be left and prices for parts and services would go through the roof because of lack of competition."

Post-2008 capital markets have proven a tough setting

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# Beyond Logistics

Airline mergers, emerging markets, and a heightened focus on parts management are shining a light on the importance of logistics

**Bob Trebilcock Keene, New Hampshire**

**P**ratt & Whitney's announcement in June that it is opening a new 600,000-sq.-ft. distribution center in New Hampshire to support the ramp-up of its new engine line was not unusual. What is different is that the facility will be operated by a third-party logistics provider—in this case, UPS.

Like other industries in which service is critical, the MRO side of commercial aviation has traditionally operated its own facilities and managed its own logistics. Given the cost of an AOG, airlines and their suppliers maintained a

provider (3PL) that specializes in parts management and logistics solutions for the commercial aviation industry.

Increasingly, some companies are turning to a third party to manage those processes for them. 3PLs like AeroTurbine, UPS, DHL and FedEx can bring tools to the table that may not be in an OEM's or MRO's tool kit, such as network design, demand planning software, and an existing infrastructure. "Airlines, OEMs, and MROs are looking to logistics providers with the expertise to control costs and manage inventory in new ways," says Tom Upshaw, UPS's director of operations for its aerospace segment. "Their challenge is not just movement but planning, so that they're not holding an excessive amount of inventory in any one location."

Several catalysts are driving logistics management and the trend for airlines to work with 3PLs.

**Mergers and acquisitions:** Airline and OEM consolidation is opening the door for 3PL relationships. "When two airlines merge, they find that their fleets overlap and they often have completely redundant warehouses and inventories," says Abelson. "In time, they're going to shed facilities and rationalize their inventory." They may even consider starting fresh with a new logistics center to support a base of operations or support the rollout of a new product, like Pratt & Whitney. "Yes, they can build a new logistics center if they want to, but why should they invest that capital when 3PLs have built

out a network to support this industry?" argues Abelson.

**Emerging markets:** Airlines may be reducing the number of flights they offer in mature markets, but emerging markets such as the Asia-Pacific region are growing. An airline may not have the infrastructure or experience to support those new opportunities, but a 3PL may already be in the region. "A 3PL like UPS has hundreds of stocking locations around the globe and experience operating in those markets," says Upshaw. "We also have parts-planning software capabilities that allow us to look in those locations at historical demand from other customers and to forecast what may be needed in the future."

**Better customer service:** Putting a part on the next flight out means that in certain regions of the country, parts aren't moving after 8 p.m. A 3PL with its own fleet, on the other hand, often takes orders until midnight for next-morning delivery. That expands the order cutoff time by up to 4 hr.

**Better parts management:** Parts management is a lot like the game of hot potato. "No one gets points for having inventory sitting on shelves in a warehouse," says Abelson. With best-in-class inventory management tools, Abelson can tell an airline or OEM partner that a part has been sitting in the warehouse for more than 60 days. Since AeroTurbine gets demand from all over the world, Abelson can sell a part that's been sitting and replace it later. "There's more to the relationship than just providing a static warehouse and filling orders," he says.

**Better fill rates:** Improved parts planning and forecasting can help a maintenance provider reduce its inventory costs. A by-product of better planning is an improvement in the first-time order fill rate in the location where the part is needed. "If we're stocking parts in multiple locations, we can do a better job of planning inventory levels in the fulfillment center that supports a specific repair depot," says Upshaw.

At the end of the day, these trends highlight that logistics is no longer just about moving a part from Point A to Point B. The increasingly sophisticated needs of the industry are resulting in equally complex solutions to control costs. ☐

UPS



**MROs work with third parties on new logistics solutions.**

surplus of just-in-case inventory positioned in numerous locations throughout the supply chain. Needed parts were often put on the next flight out.

Logistics today is about more than just storing and moving a lot of just-in-case parts. Given that fuel prices and labor costs are relatively fixed, inventory and logistics represent an area where maintenance providers can reduce their costs. "If an airline is spending a billion dollars or more a year on materials and 60% of that is in parts, there's an incentive to turn that number down," says Joshua Abelson, senior vice president-supply chain solutions, for AeroTurbine, a third-party logistics

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# From Surviving To Thriving

## Icelandair prepares for fleet renewal and diversification

**Tom Pleasant** **Reykjavik, Iceland**

**T**he Icelandic banking collapse of 2008-11, followed by the eruptions from the Eyjafjallajökull volcano in 2010, took a strong Icelandair and crushed it.

"I remember when we had to sell spare engines just to be able to pay salaries," says Jens Thordarson, vice president-technical operations. "It was a very, very rough time for the company."

The airline not only has survived but it is now thriving. Over the last five years, operations have doubled. New destinations and services include Anchorage, Alaska; Birmingham, Alabama; Boston; Edmonton, Alberta; Geneva; Minneapolis; New York; Orlando, Florida; Seattle; Vancouver; and Washington. In February 2013, the company ordered 16 new Boeing 737 MAXs.

This expansion of the fleet and network is obviously having a knock-on effect for the technical division. "We've been busy to say the least," laughs Thordarson, "especially in the summer months. Usually after that, we have a quiet start to the winter with C checks and installing cabins into new aircraft. There is talk, though, of trying to even out seasonal peaks, which I do recognize would be a great thing for the rest of the company; but we're one of the few disciplines that actually benefits from the peaks and troughs."

To cope with this increased demand for their time, the division is conducting an efficiency drive to make better use of its staff and hangar space.

"We've recently been hitting a sweet spot on labor utilization," says Thordarson. "But the utilization of the hangar could be better," he admits. "Staff shortages are preventing us from working multiple shifts because we just don't have enough qualified mechanics. We've tried to change that, with a lot of people going through their studies, but that's a four-to-five-year process"—a long-term project.

"Still, we're starting to see some tangible improvements, although we're really only touching the surface of what we would like to make. There are still plenty of areas just waiting to be tackled," he says.

When more efficiency creates more flexibility, Thordarson wants the division to start looking again at third-party contracts. While more than 90% of the division's work is still for Icelandair, about 40% of its spare parts business is for third parties, such as Russia's Yakutia Airlines. Thordarson says he wants that business—and similar areas—to grow.

However, he says the current skills shortage will limit those activities to spare parts and Boeing 757 technical management until more engineers are trained.

The Boeing 757 is the backbone of the Icelandair fleet, which is made up of 20 -200s and one -300, largely sourced from American Airlines. The carrier also has nine 737 MAX 8s and seven MAX 9s on order, with options for an additional eight for delivery through 2018-21. Being so specialized on one aircraft type does raise the question of how ready the division will be to handle newer types.

"They say it won't be a big deal transitioning between them, but we won't know that until we are actually doing it," says Thordarson. "Still, I don't think it will be much of a problem."

The influx of new aircraft also has a trickle-back effect on decisions for the ongoing upgrade and refurbishment of 757 cabin interiors. Thordarson expects any decisions on the next iteration of interior changes will be made around mid- to late-2015, and he is confident that won't slip. Even so, going from a single fleet to a dual one will add complexity to the division's operations.

**The Boeing 757 is the backbone of the Icelandair fleet.**



"We will definitely be looking at suppliers that can help us accommodate both [757s and 737 MAXs], but we will keep our options open. There are certain things you can do on MAXs that you just can't on a 757 and [vice-versa]," he says.

"It will be all about making a comparable product across the two types that won't impact the passenger experience, which is exceptionally important. That is why—while it's not something that airline people like to talk about publicly—you have to be careful of an aging fleet," says Thordarson. Passengers so far have responded favorably to Icelandair's cabins.

As the new aircraft come online, their seats, Thordarson says, are likely to remain the current Aviointeriors products. That will leave two main areas for consideration: inflight entertainment (IFE) systems and paneling.

Ten years ago, the airline had several different types of IFE systems. This was standardized to a single type from Thales in 2006, but some of the newer aircraft now have IMS RAVE. Thordarson says Icelandair does not have any definite plans to retrofit the Thales system out of the fleet, but it is evaluating it as an option. The airline also is deciding whether to repair existing or buy new paneling, and expects to decide by mid-year.

Meanwhile, mood lighting—already installed and allowing cabin interiors to mimic the Northern Lights for which Iceland is so famous—is enjoyed on several aircraft and will be rolled out across the fleet starting this winter, as well as Wi-Fi from Row44, already on eight aircraft.

No matter what the engineers do, however, every passenger aircraft eventually has to be retired. "There's talk of converting some of the retiring 757s—in 10-15 years—into freighters, but we don't have the capability to do that ourselves," says Thordarson. "Never say never, though," he adds.

"We will definitely have a need for the 757 for a long time, so we're focusing on securing the resources to support this aircraft for at least a decade, probably more. It won't stop being a part of our passenger fleet before 2025." ✈



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# Preemptive Practices

Pratt & Whitney's operations center monitors suppliers to proactively ensure timely engine builds

**Lee Ann Tegtmeier** East Hartford, Connecticut

**L**ike an eagle that uses its keen vision, strength and size to become apex predator of the aviaries, Pratt & Whitney believes its PW1000 geared turbofan will be the eagle in its nest to make its commercial production soar (*AW&ST* May 26/June 2, p. 36). As it prepares its geared turbofan for commercial flight—and engine production volume to double over the next five years—company leaders have coalesced their efforts to ensure there is no single point of failure across the enterprise, from raw material to aftermarket support.

Using the opportunity for the ramp-up, Jill Albertelli, vice president-supply chain, working with other leaders across the UTC aerospace division, said, “let’s figure out how we do this differently.” And not just differently, “game changing.”

Albertelli, formerly vice president of materials management where she cut parts delivery times and im-

**Pratt & Whitney delivered the first set of PW1100G-JM engines to Airbus for the A320neo. Pratt plans engine certification for the second half of this year.**

proved forecasting accuracy, pointed out that “you hear about advancements in manufacturing technology,” but “how do we get people to talk about advancements in the supply chain?” That dialogue is what she achieved.

For starters, she took a fresh look at the 24-hr. help desk—on the front line of customers’ needs—and adapted the concept to proactively look at suppliers. The key is proactive—set expectations early, provide as much information as early as possible, and collaboratively work with suppliers to anticipate any snags before they occur. Set expectations—but also commit to assist partners.

This has resulted in Pratt signing \$10 billion in long-term supplier agreements—which could be for five or 10 years—or a program approach to ensure no single point of failure. While natural disasters can’t be prevented, placing strategic tooling at another location can help to hedge risk.

This all comes together in one room—the operations center in East Hartford, Connecticut, opened in November 2013 to mitigate problems in engine builds and monitor 45,000 parts. Based on the best practices from a similar center at Pratt & Whitney Canada, suppliers send information daily through a portal so P&W can prioritize any problems via tens of millions of data points. The OEM looks 12-18 months ahead to watch for problems or trends going in the wrong direction—then

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works with suppliers as early as possible to correct them.

Pratt also monitors suppliers' capacity, demand, input, buffers, yield and work in progress for deliverables 12 weeks out to make sure they align with its suppliers. With the ramp-up, "we make it very clear that quality and on-time performance are very important," and the company tracks corrective actions and their resolutions, says Albertelli.

The OEM scores suppliers' performance and depending on that rating, will meet with suppliers weekly, monthly or quarterly to make sure they are on the same page. While some suppliers still require weekly meetings—and most of those are in the development phase as opposed to full component production—Albertelli says the number that must do so is dropping.

Experts from quality assurance, manufacturing and supply chain staff the ops center "to lead the charge across engine builds," says Albertelli. They use heat maps with delivery dates, scatter diagrams and other graphics to assess deviations, then take action.

Before the ops center opened, priorities could be based on "who screamed loudest or first," she says. But "now we use data to support work issues that should be dealt with first."

To get there, both Pratt and suppliers needed training to understand what is truly an alert versus something as simple as missing information. Albertelli says the OEM worked very closely with suppliers to help them understand what data to provide and exactly what it will be used for.

She says they appreciate the collaborative process—which can even include Pratt providing ACE delivery and quality clinics—and the longer-term business.

The process has built trust in P&W's supply base, which she feels is stronger because of it, and it is a two-way street. "They also proactively call us now, from equipment being down to having to work with an alternative supplier," she says. But it's okay if they call with a problem and need a solution. That's part of the collaborative relationship.

"We strive for our suppliers to be 98% on-time or above," and "we are close to that with a significant portion" of P&W's 400 suppliers base, says Albertelli. "They really are an extension of our team," and "they bring options that are creative and innovative which will bring us to the next level. They see the long-term opportunities, they see the collaboration, and they are willing to try something new and innovative," she says. 🌐

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# Better, Cheaper

## Can upgrades and cheaper overhauls keep Trent 500 operators happy?

Sean Broderick **Washington**

**A** decade of rising fuel prices and the emergence of better big twins has the Airbus A340 on the ropes. Yet of all the model's supposed weaknesses, manufacturer complacency is not one.

Airbus and its engine suppliers are positioning newer A340s as viable options for both second-tier operators and bigger carriers waiting to take newer, more efficient widebodies. Arguably the most aggressive has been the company with a reputation for being inflexible: Rolls-Royce.

The manufacturer is taking steps to reduce engine-related operating costs for the newest A340s, the -500s and -600s, powered exclusively by Trent 500s. The most publicized move, an-

nounced late last year, is Rolls's "four for two" campaign that strives to cut the four-engine A340's maintenance costs to those of a widebody twin.

The offering includes many elements of a broader program dubbed TotalCare Flex that Rolls is developing.



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Building on the TotalCare long-term aftermarket support program, Flex would fold in options to lower life-cycle costs, such as more surplus parts and an engine exchange program to defray overhauls, says Peter Johnston, head of marketing for Rolls large civil engines.

Neither concept is new, but they are newer at Rolls than at other manufacturers. Long a hard-liner on aftermarket support options, Rolls has an estimated 90% of the Trent family under TotalCare, TeamSAI calculates. The company also has long been third among enginemakers in surplus parts consumption. Industry estimates put Rolls's annual surplus consumption

**Four-for-two lowers costs, but fuel-saving upgrades offer more promise.**

at \$100 million—about half of Pratt & Whitney and a fraction of GE's industry-pacing \$700 million. TotalCare Flex should change that.

Rolls also is tapping joint venture partners, like Lufthansa Technik (LHT), to reduce engine overhaul costs.

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Rolls and LHT are equal partners in N3, a Rolls-focused overhaul center and one of four Trent 500 shops.

The Trent 500 entered service in August 2002. The next few years were not kind to the four-engine jet market. Widebody twins continued to evolve and fuel prices jumped fourfold by 2008. Add in some teething problems, and the redesigned A340s were navigating strong headwinds.

Rolls in 2006 introduced the Trent 500 Enhanced Performance (EP) build standard and retrofit kit, found on 70% of the 590-engine fleet. The EP improved efficiency but the headwinds persisted, leaving the A340—like all four-engine aircraft with competition—battling eroding market share.

Faced with flagging demand and pressure to trim operating costs, Rolls last year put together its latest Trent 500 support offering. While the four-for-two plan receives the most attention, Johnston says a new upgrade, dubbed EP+, holds more promise.

The modification includes elliptical leading edge blades in the intermediate

and high-pressure compressors, which Rolls says trims fuel burn 0.5%, meaning \$170,000 in fuel savings per aircraft per year. Add in the company's fuel management program and the figure approaches \$300,000, Johnston says.

The upgrades, which work on both Trent 500 and 500EP configurations, have been available for a year and incorporated by three customers. "The first measurements we're getting back from the fleet look very good," Johnston says.

Rolls calculates that fuel makes up 40-50% of total A340-500/600 operating costs; maintenance accounts for 5%. Johnston says those figures guide Rolls on how to focus its resources.

"If we want to spend our money, we're getting our biggest bang for the buck by reducing fuel burn," he says.

Both Rolls and Airbus concede that A340-500 and -600 operating costs will never come down to those of newer twins. But factor in capital costs of newer, higher-demand aircraft like a 777-300ER, they argue, and the competition intensifies. Airbus, eyeing charter operators and the emerging

long-haul low-cost market, is working to boost A340-600 certificated capacity 35 seats to 475 seats.

The manufacturers hope their efforts will help make A340s more attractive to operators like Lufthansa and Iberia that have placed long-haul fleet replacement orders and have to decide what to park when. Another target: second-tier operators such as wet-lease operator HiFly, which has six A340s—including two A340-500s and an A340-600—in its fleet, and Azerbaijan Airlines, which leases a pair of A340-500s.

"We are just starting to see the first of the second-tier and smaller airlines come in now," Johnston says. "We see a lot of potential there."

Aviation Week's MRO Prospector projects that 65% of the Trents in service—380 engines—will undergo overhauls in the next three years, generating \$1.2 billion in work. Worth watching is how many operators add EP+ during their overhauls. This will provide strong indication of the Trent 500's longer-term market, as well as the A340-500's and -600's futures. ☛



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## Washington

## Fighting Flight Deck Fires

The FAA, acknowledging that flight crews need to be better prepared to combat flight deck fires, has drafted a policy that is meant to amplify and augment existing rules and guidance, but stops short of modifying its regulations.

The draft policy, "Flightcrew Procedures and Training for Addressing Fire Hazards in the Flight Deck," would close a perceived gap in existing guidance that focuses on the cabin rather than the flight deck.

### New FAA policy will help pilots prepare to fight flight deck fires.

A 2004 advisory circular (AC), AC 120-80, emphasizes cabin crew procedures for handling inflight fires since that is where they are most likely to start. The AC was published as a response to NTSB recommendations made in 2001 targeting inflight fires. NTSB's recommendations were based on probes of inflight fires starting in cabins, and the guidance focuses on general firefighting awareness among cabin crewmembers. While that guidance can be applied to the flight deck, FAA determined that operators would benefit from more tailored information.

The FAA's actions came in part based on the probe of a 2010 flight deck fire aboard a United Airlines Boeing 757 en route from New York to Los Angeles. Shortly after reaching a cruise altitude of 36,000 ft., the pilots detected smoke and then flames coming from the glare shield, NTSB said in its report. They donned their permanently installed oxygen masks and began troubleshooting. The captain handled firefighting duty, but struggled to keep his mask on as he moved from his seat to reach the fire extinguishers.

"The extinguisher was not reachable from his seat because it was located on the back wall of the cockpit behind his seat," NTSB's report explained. "As he reached for the Halon bottle, his oxygen mask and goggles were torn off because he moved beyond the reach of the oxygen mask hose. He retrieved the Halon bottle, re-donned his mask and goggles, and discharged the bottle."

But the fire did not stay out, and the captain elected to retrieve another extinguisher from the cabin. His oxygen mask again came off when he stood up to take the extinguisher from a flight attendant at the cockpit door.

The flight crew got the fire under control and, despite a badly cracked windshield, made an emergency landing at Washington Dulles International



Airport. The fire was traced to a well-established deficiency in the aircraft's windshield heating system.

Following the probe, FAA's internal review of its regulations determined that, despite the challenges and the dangerous situation the captain faced when he lost his mask, the 757 was properly equipped and the crew acted properly.

"As long as there is a fire extinguisher located in the flight deck that is clearly marked and flight crew members have unobstructed access to it, then the fire extinguisher installation would meet the applicable part 121 operating regulations" and related guidance, the policy explains.

FAA's regulations require emergency equipment—such as extinguishers and both fixed and portable protective breathing equipment (PBE), to be "conveniently located" and "readily accessible" by the crew.

"For emergency equipment to be considered conveniently located and readily accessible, the flight crew should have clear and unobstructed access to it, but not necessarily while seated or while wearing equipment intended for use while seated," FAA notes in the policy. "For example, ac-

cessibility of each piece of equipment should be assessed by itself."

However, FAA's policy notes that consideration should be given to the ramification of pilots having to leave their stations to retrieve safety equipment.

"If procedures advise the flight crew to exit their seats to combat a fire, then it should be shown that ei-

ther there would be sufficient time and air flow to do so without the use of PBE, or emergency equipment should be within the flight crew's reach while wearing an oxygen mask," the policy says.

The agency also suggests that flight crew firefighting training emphasize that portable PBEs are best for fighting fires, and the fixed PBEs should be

used while operating the aircraft to protect against smoke, fumes, and fire.

Training should also emphasize turning to the cabin crew for help fighting onboard fires, so the flight crew can focus on operating the aircraft.

"If the source of fire is confirmed to be in the flight deck but is not obvious, or cannot be extinguished quickly enough such that PBE is necessary, procedures should emphasize that the flightcrew request immediate assistance from available cabin crew so that the flightcrew can continue to operate the airplane and prepare for emergency landing as necessary," the policy emphasizes.

FAA is accepting public comment on the draft policy statement through July 17 via: [www.faa.gov/aircraft/draft\\_docs/policy](http://www.faa.gov/aircraft/draft_docs/policy). ☐

—Sean Broderick

## Europe

## A Sharper Tool

Europe has enacted regulations that should make its decade-old centralized safety database more valuable to both regulators and state aviation agencies by expanding the amount of incident

information available to its users.

The regulation, adopted in April and taking effect late next year, opens up access to records in the European Central Repository (ECR) to safety agencies and investigators throughout Europe.

"One of the current difficulties of the ECR is that the narratives from occurrences are only available to the country who submitted the data in the first instance," EASA explains in its recently released 2013 Safety Review. The new regulation, "Reporting, Analysis and Follow-up of Occurrences in Civil Aviation," says "safety-related" information in ECR records "should be available" to civil aviation authorities and accident investigators.

"This will be a significant step forward and will have a positive effect on the use of the ECR for safety analysis purposes," EASA says.

The new regulations also establish standards for everything from reporting incidents to protecting safety data, including national-level appeals processes. While the rules reach far beyond ECR, improving the region's primary safety databank should be one of their most significant contributions.

Created in 2003 to support the European Coordination Centre for Accident and Incident Reporting System, the ECR houses 800,000 records detailing accidents and incidents from the last decade in all types of operations. All 31 EASA member states have been contributing since 2011, and new records are added at a rate of 80,000-90,000 per year.

While legislation is helping the ECR's holdings become more available, only diligence will address its biggest shortcoming: data quality.

Nearly half of the ECR's records lack the most important piece of classification information: the type of operation. Since 46% of the records were generated by commercial air transport operations, it is a good bet that most of the unclassified ones were as well. But ensuring higher quality data is recorded—mostly as new entries, but occasionally by updating existing ones—is key to having the ECR realize its potential as a stand-alone safety trend-spotting tool.

"The number of occurrences in the ECR is continuing to grow every year and, most important, the quality of data

has improved significantly over the past few years," EASA says. "The challenge is to continually improve the quality of the data provided by the member states so that the ECR is able to provide enough detailed information to support the decision-making process in its own right without the need to refer to other data or information sources."

While EASA is still developing the

ECR as a predictive tool, the data aggregation yields some notable perspective. At the end of 2013, the most common outcome of an incident was a missed approach, which occurred in 14,500 of the ECR's records. A year earlier, missed approach was a close second behind "aircraft return," which fell to second, with 13,500 occurrences. ☛

—Sean Broderick

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Regina Kenney **Chicago**

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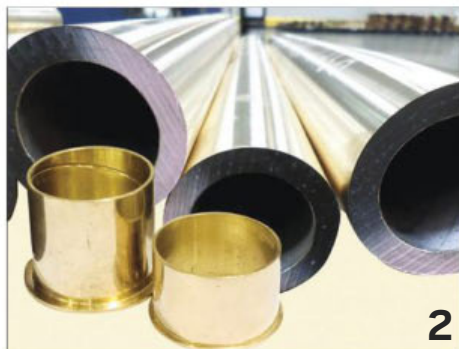
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**Offering:** VAS Aero Services, an aviation parts supplier, offers distribution services to the aftermarket and OEMs including Boeing, GE, Embraer, Hamilton Sundstrand and Honeywell. Offering more than 900,000 different part numbers to its global customers, VAS can provide items from landing gears for a commercial jet to critical components of the latest turbofan engine.

[www.vas.aero](http://www.vas.aero)

**Link 620**



10

### 11. OEM and PMA Parts

**Supplier:** Able Aerospace

**Offering:** Able Aerospace offers a large inventory of OEM parts or FAA-approved PMA alternatives. The approved replacement parts are in stock at all times and customers can nominate candidates for approved replacements on the Able Aerospace website. The core product listing includes airframe, propulsion and cabin safety parts and assemblies applicable to McDonnell Douglas and Boeing aircraft including components such as Honeywell APUs used on the Boeing 757; seat tracks for the 757 and 767; and 757 passenger door hinge link and cam basket assemblies.

[www.ableaerospace.com](http://www.ableaerospace.com)

**Link 621**



12

### 12. Replacement Parts

**Supplier:** Wencor

**Offering:** Offering more than 150,000 parts in stock, Wencor allows customers to search and order replacements for most major systems in commercial aircraft. These include Mil-Spec, TSO, OEM and PMA parts made by the top-tier manufacturers. With a 48-hr. standard delivery, Wencor ships 155,000 pieces a day and has more than 6,000 customers worldwide.

[www.wencor.com](http://www.wencor.com)

**Link 622**

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Madrid, Spain

**Be part of Europe's leading event where airlines, MROs, suppliers, OEMs, regulators, lessors, and industry experts converge to define the aviation maintenance industry!**  
Foster new relationships, connect with existing ones, and expand your reach across the MRO community.

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February 2-3, 2015  
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### AIRFRAMES

#### The Boeing Edge. Focused on your needs.

The Boeing Edge is the industry's largest portfolio of services, support and solutions. We've organized it around your business to give you the advantage it takes to succeed, to optimize the performance of your airplanes and operations. All backed by the knowledge and experience only Boeing can provide.



**Boeing Commercial Airplanes**  
[www.boeing.com/boeingedge](http://www.boeing.com/boeingedge)

Link 065

### AIRFRAMES

#### Worldwide Base and Line Maintenance Fuel Systems Support

FFCS provides world-wide fuel system support that includes fuel leak detection and repair, removal and replacement of all fuel system components, fuel quantity calibration, fuel migration detection and structural repairs. FFCS has the only manned 24 x 7 Operations Control Center that coordinates, monitors and controls all aspects of all work performed.



**FFC Services, Inc.**  
[www.ffcfuelcells.com](http://www.ffcfuelcells.com)

Link 317

### CLEANING

#### ARMEX® Blast Media – The MRO Abrasive

Eliminate particle ingress with this water soluble baking soda based abrasive from the makers of ARM & HAMMER® products. Use safely on various components, even those with complex surfaces and passageways. Safe for sensitive substrates. No pitting, peening or crack closure. Excellent for NDT prep.



**Church & Dwight Co., Inc./ArmaKleen Company**  
<http://www.armex.com/>

Link 040

### CLEANING

#### The Bicarbonator Soda Blast Cabinet

AEROLYTE soda-blast cabinets with patented Clear View ventilation offer the best visibility on the market, maximizing productivity and performance. Designed for soda media, parts cleaning, and coating removal. Standard and engineered models. Visit our web site to view soda blasting in action.



**Clemco Industries Corp.**  
[www.clemcoindustries.com](http://www.clemcoindustries.com)

Link 081

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### COMPONENT REPAIR

#### AeroParts — first class performance

AeroCOAT™ restores ozone converter cores up to 99% efficiency providing maximum performance at minimum cost with quick turn-time. The flexibility and adaptability of our drop hammer capabilities allows us to shape complex metal forms restoring damaged ducts that others would throw away.



**AeroParts Manufacturing & Repair, Inc.**

[www.aeroparts.aero](http://www.aeroparts.aero)

Link 286

### COMPONENT REPAIR

#### RAT, ADG, IDG & APU Generator Repair

Aerosource, a member of the Safran Group, is the OEM for the MD11 Air Driven Generator, KC390 Ram Air Turbine, and various other products with military applications. Our FAA/EASA/ANAC approved repair station specializes in RATs, ADGs, IDGs, APU Generators and Hydraulic Pumps for all aircraft types.



**Aerosource Inc.**

<http://www.aerosourceinc.com/>

Link 018

### COMPONENT REPAIR

#### Affordable Thermal Spray Equipment

Bay State Surface Technologies, a subsidiary of Aimtek, has been providing quality, operator-friendly plasma and twin-wire arc spray equipment and materials for over 50 years. Complete turn-key solutions, including booths, robots, dust collection, turntables, parameter development, and training.



**Aimtek**

[www.baystatesurfacetech.com](http://www.baystatesurfacetech.com)

Link 511

### COMPONENT REPAIR

#### Fabrication and Refurbishment Services

Precision fabrication, finishing and refurbishment services. Our lapping, grinding, polishing, diamond machining and honing services are used to produce everything from gears, shafts, wobblers and seals to hydraulic cylinders. Metals, ceramics, glasses and hard coatings. ITAR registered.



**CMPC Surface Finishes**

[www.surfacefinishes.com](http://www.surfacefinishes.com)

Link 732

### COMPONENT REPAIR

#### Dynatech Repair/Overhaul Management Services

Dynatech's Repair/OH Management programs deliver added value by giving you a single point of contact for all of your needs. Dynatech offers repair/OH services, OH exchange programs or outright sale of OHC spares from inventory. We'll work with you to customize a program to suit your specific needs.



**Dynatech International LLC**

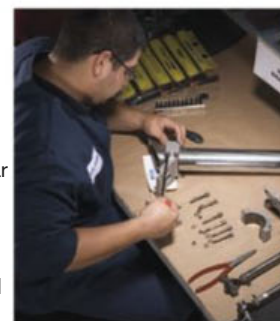
[www.dynatechintl.com](http://www.dynatechintl.com)

Link 579

### COMPONENT REPAIR

#### Engine Mounts, Wire Harness & QEC Components

Hutchinson Aerospace Overhaul and Repair strategically located in North America, Europe, and the Far East, including China; focusing on overhaul and repair of Barry and Non-Barry Engine Mounts, Wire Harnesses, QEC components and specializing in CFM56 and Trent 800 engines.



**Hutchinson Aerospace/Barry Controls**

[www.hutchinson-na.com](http://www.hutchinson-na.com)

Link 129

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## COMPONENT REPAIR

## Better Service, Longer Life

Since 1953 we have provided quality repairs, overhauls and spares to OEM's, Airlines, Rotorcraft and Military customers alike. Quality and Reliability are number one. Large or Small, our support team is ready to help you. Contact us to see why your competitor is using L. J. Walch Co repairs.



**L. J. Walch Co., Inc.**

[www.ljwalch.com](http://www.ljwalch.com)

Link 309

## COMPONENT REPAIR

## Welded Bellows Products Repairs and Spares

Senior Aerospace Metal Bellows FAA/EASA certified repair station offers a full range of repairs primarily focused on edge welded metal bellows assemblies. These include potable water system compressors, bellows seals and oil pressure sensors.



**Senior Aerospace Metal Bellows**

[www.metalbellows.com](http://www.metalbellows.com)

Link 815

## COMPOSITES

## BASF Aerospace Materials

Aerospace materials from BASF include a broad portfolio of products and technologies that can provide unique solutions across a wide range of applications — cabin interiors, structural materials, seating components, fuel and lubricant solutions, coatings & specialty pigments, as well as flame retardants & fire protection.



**BASF**

[www.aerospace.basf.com](http://www.aerospace.basf.com)

Link 316

## CONSULTING SERVICES

## AVIATION INDUSTRY DESIGN

**BRPH** is an international architecture, engineering and construction services firm specializing in aviation facility design. From 10,000 square foot operation centers to 1.2 million square foot assembly buildings, we are experts in complex aircraft manufacturing plants for the world's largest aviation companies.



**BRPH Architects - Engineers, Inc.**

[www.brph.com](http://www.brph.com)

Link 900

## CONSULTING SERVICES

## PlaneTechs Aviation Workforce Solutions (Staffing)

PlaneTechs provides aviation contract personnel for aircraft maintenance, repair, overhaul and manufacturing projects in the commercial and DoD/ Govt. sectors. As the nation's largest provider of aviation mechanics and technicians, PlaneTechs makes it easy for our clients to staff their projects and keep them running safely, on time and on budget.



**PlaneTechs**

[www.planetechs.com](http://www.planetechs.com)

Link 183

## ECONOMIC DEVELOPMENT

## Where Aviation is Going

The Global TransPark (GTP) is a 2,500-acre industrial park with access to air, rail, highways, international ports, and the Spirit AeroSystems Composite Center. Real estate at GTP includes sites from five to 300 acres. Existing facilities include manufacturing spaces, hangars, warehouse and office.



**North Carolina Global Transpark**

[www.ncgtp.com](http://www.ncgtp.com)

Link 504

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### ELECTRICAL COMPONENTS

#### Electronic Manufacturing Services

Arc-Tronics is a full-service Electronic Manufacturing Services (EMS) provider for printed circuit board assembly, cable/harness assembly, and complete box build. The company is ISO 9001:2008, ISO 13485:2003, and AS9100 Rev. C certified. Arc-Tronics is also an ITAR registered company.



**Arc-Tronics, Inc.**

[www.arc-tronics.com](http://www.arc-tronics.com)

**Link 934**

### ELECTRICAL COMPONENTS

#### A320 Landing Gear Harness Repair

Servicing both OEM & Aftermarket with repair, overhaul & replacement. Capabilities include repair or replacement hardware for the entire aircraft, from engine and airframe to APU, landing gear, ECS and all subsystems. Specializing in Harness Assemblies & Temperature Sensors.



**Harco**

[www.harcolabs.com](http://www.harcolabs.com)

**Link 121**

### ENGINES

#### Engine Field Service, Sales & Exchange

LCI, a FAA/EASA Repair Station, provides services such as MPA runs, Removals/Installations, DVD Borescope Inspections, Repairs, Conversions, Preservation and Storage, Component Changes, QEC Kit Builds/Swaps, Tear-downs, Top-case Repairs, Asset/Lease Pool Management, and Technical Support.



**LCI**

[LCI.aero](http://LCI.aero)

**Link 145**

### ENGINES

#### OEM approved repair of mainshaft bearings

SKF Aeroengine Services offers full-service bearing repairs for the world's leading Aero and Industrial engine programs. We service both commercial and military end-users, offering four levels of repairs for many aeroengine applications.



**SKF Aerospace**

[www.skf.com/us/services/aeroengine-services/index.html](http://www.skf.com/us/services/aeroengine-services/index.html)

**Link 518**

### EXPENDABLES

#### Distribution, Manufacturing & Repairs

Leader in stocking distribution, parts mfg and MRO services. Honeywell thermal switches & accelerometers, Triumph interiors, Engine OMAT materials, Boeing licensed PMA's, EGT repair services, circuit breaker I.D. collars, engineering and fabrication services. AS9100C, ASA-100 FAA/EASA certified.



**LKD Aerospace**

[www.lkdaerospace.com](http://www.lkdaerospace.com)

**Link 774**

### GSE

#### Engine Transport Stand, Handling and Support Equipment & Aircraft Maintenance Docks

AGSE is the WORLD LEADER in the design and manufacture of Whole Engine, Split-Ship and Rollover Stand Systems. Broad Range of OEM Licensed Engine Transportation & Handling Systems. Worldwide Presence, AGSE & Westmont are the Global Leaders in the Design and Manufacturing of State-of-the Art Engine Handling Systems. Our GSE products are renowned for their Ingenuity, Durability and Ease of Maintenance.



**AGSE WESTMONT**

[www.agsecorp.com](http://www.agsecorp.com)

**Link 570**



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## GSE

## Split, Rollover and Ship Dolly Engine Stands

As a global leader in the design, development, testing & manufacturing of shipping & storage containers & GSE for aviation, military, power generation & space programs, our manufacturing capabilities cover all metal working requirements for carbon steel, aluminum, stainless steel & other materials.



## Champion GSE

[www.championgse.com](http://www.championgse.com)

Link 825

## HANGAR EQUIPMENT

## The Global Leading Supplier in Aircraft Hangar Doors

ASSA ABLOY's Megadoor brand delivers exceptional access for the aviation industry. More than 15 000 doors installations make ASSA ABLOY Entrance Systems a global leader in vertical lift fabric door systems. Designed to meet any size or wind load, it is the most energy-efficient door on the market.



## ASSA ABLOY Entrance System

[www.megadoor.com](http://www.megadoor.com)

Link 323

## HANGAR EQUIPMENT

## Heavy Structures, Pre-Engineered Buildings

Specializing in large hangars for commercial, military and general aviation, Heavy Structures provides inspired solutions for complex buildings. For an economical hybrid structure, we offer you the economy and speed of a pre-engineered building system without sacrificing quality or appearance.



## Heavy Structures

[www.heavystructures.com](http://www.heavystructures.com)

Link 717

## HYDRAULICS/PNEUMATICS

## Component &amp; Accessory Repair and Overhaul

Component MRO since 1988 - specializing in Hydraulic/Pneumatic/Electric Actuators, Ballscrews/Gearboxes, Pneumatic/Electromechanical Valves and Components, APU Valves, Exciters, Sensors/Selectors, Transducers, Harnesses/Cables, and Pressure Switches. Offering OEM, PMA & DER cost reduction solutions.



## Harter Aerospace

[www.harter.aero](http://www.harter.aero)

Link 122

## HYDRAULICS/PNEUMATICS

## Pneumatic/Fuel Component Repair &amp; Overhaul

Texas Pneumatic Systems, Inc. has complete high flow, high heat pneumatic capabilities including all starters, air cycle machines, PDU's cooling turbines, and valves for military and commercial aircraft. Turbine Fuel Systems, Inc. has capabilities for most submersible and engine driven pumps, APU fuel control, and general fuel accessories for most commercial aircraft.

## Texas Pneumatic Systems, Inc./

## Turbine Fuel Systems, Inc.

[www.txps.com](http://www.txps.com)

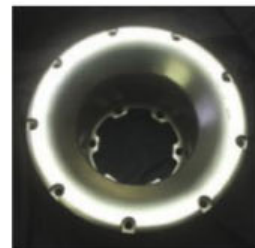
Link 221



## LANDING GEAR, WHEELS, BRAKES

## Wheel &amp; Brake Repair, Specialized Services and Techniques

T.T. Repairs, LLC is a certified FAA and EASA approved repair station. Our primary focus is servicing all wheel and brake components. We also offer a variety of specialized services and techniques. This includes custom tooling and fabrication, NDT, thermal spray, welding all metals, machining, plating, shot peen & much more.



## T.T. Repairs, LLC

[www.ttrepairs.net](http://www.ttrepairs.net)

Link 878

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### METAL

#### Valve Body Chrome Repair

Hard chrome and precision grind repairs; Aluminum, titanium, Steels, Inconel; Competitive turn-times and pricing; Superior quality - plating and finish grind; One-Stop provider (manage other processes).

Contact 562-437-2825 or [sales@aviation-repair.com](mailto:sales@aviation-repair.com)



**Aviation Repair Solutions**

[www.aviation-repair.com](http://www.aviation-repair.com)

Link 049

### MRO SERVICES

#### Acme Aerospace: Battery Maintenance, Repair & Overhaul

Acme provides MRO services on batteries of all chemistries, including individual cell scanning & diagnostics, temperature monitoring and automated services for NiCad, Lead-Acid, and Sealed Cell FNC. Acme offers FREE

battery pick-up and delivery to all customers in and around the Phoenix-Metro Area.



**Acme Aerospace Inc.**

[www.acme-aero.com](http://www.acme-aero.com)

Link 907

### MRO SERVICES

#### Aero Controls, Inc. Component Repair Solutions

Specializing in overhaul repairs and component Sales, Aero Controls, Inc. is a FAA certified repair station # IU6R626N that has built its reputation based on quality products and services. We are committed to providing the best value to our customers and continually set the standard in aerospace technologies.



**Aero Controls, Inc.**

[www.aerocontrols.com](http://www.aerocontrols.com)

Link 290

### MRO SERVICES

Like our cousin Jerry, after 40 years we finally left home.



**Aviation Technical Services**

[www.atsmro.com](http://www.atsmro.com)

Link 050

### MRO SERVICES

#### Exceptional Repair Service at a Fair Price

Camtronics is a leader in the MRO business



with a diverse capability list along with a long list of satisfied customers. As a Boeing service facility we pride ourselves on being a "customer service" company and building relationships through reliable service and innovative repair development.

**Camtronics MRO**

[www.Camtronicsllc.com](http://www.Camtronicsllc.com)

Link 711

### MRO SERVICES

#### Commercial Jet - Advanced MRO Solutions

For over 25 years, Commercial Jet has been serving Airbus and Boeing passenger and cargo airlines, owners, lessors and military. Located in Miami, Florida (MIA) and Dothan, Alabama (DHN), the company boasts over half-a-million square feet in modification and MRO repair station capacity.

Advanced MRO Solutions for Boeing and Airbus

**COMMERCIALJET**

- Heavy Maintenance
- Structural Repairs
- Avionics Upgrades
- VIP Modifications
- Line Maintenance
- NDT Inspections

**AEI Conversion Center**



**Commercial Jet**

[www.CommercialJet.com](http://www.CommercialJet.com)

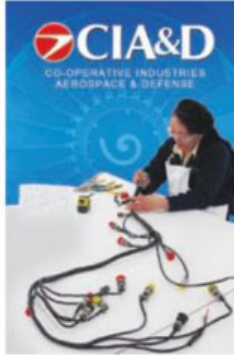
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## MRO SERVICES

## Certified Wiring Harness Repair Services

When you select our FAA/EASA/CAAC certified Repair Center you can rely on experienced technicians that deliver quality workmanship and responsive turn times. Specializing in GE90, CF6-80C, CFM56-7B, CFM56-5A/B/C, PW4000 QEC and others, you can count on CIA&D for reliable wiring harness solutions.



**Co-Operative Industries Aerospace & Defense**

[www.coopind.aero](http://www.coopind.aero)

Link 085

## MRO SERVICES

## Rethinking business as usual

CTS Engines is the world's leading independent mature engine MRO. We focus on engine maintenance for late lifecycle engine models, including the CF6-50, CF6-80, CFM56-3, and CF34-3 engine types, and provide our customers with outstanding quality and exceptional customer service.



**CTS Engines**

[www.ctsengines.com](http://www.ctsengines.com)

Link 313

## MRO SERVICES

## Delta TechOps Certified Full Service MRO

Leverage the unparalleled efficiencies and global reach of the world's third largest airline MRO to keep your fleet in the air. LEAN and Six Sigma processes and ISO certification allow Delta TechOps' experienced and dedicated workforce to provide high quality service to meet your maintenance needs.



**Delta TechOps**

[www.deltatechops.com](http://www.deltatechops.com)

Link 092

## MRO SERVICES

## Customer Focused Value Driven Solutions

ITT Aerospace Controls manufactures Valves, Actuators, Pumps, Pressure and Temperature Switches. ITT Aerospace Controls provides the following MRO Services: Exchanges, Distribution, PMA Solutions, AOG Support and a full complement of Maintenance Services through our FAA Approved 145 Repair Station.



**ITT Aerospace Controls**

[www.ittaerospace.com/aftermarket](http://www.ittaerospace.com/aftermarket)

Link 772

## MRO SERVICES

## Liebherr-Aerospace - Experience the Progress

Liebherr-Aerospace offers complete air management, flight control and landing gear systems. With the certified disciplines of development, production, qualification, integration and customer services, Liebherr combines innovative practices and high modularity to fully fit customers' requirements.



**Liebherr-Aerospace Saline, Inc.**

[www.liebherr.com](http://www.liebherr.com)

Link 906

## MRO SERVICES

## One-Stop Shop Adapted to Meet Customer Needs

PAS Technologies is the premier special process integrator for commercial aerospace and military markets. One-Stop Shop capabilities include custom processes for engine and airframe components. Operational excellence in OEM and MRO solutions mean unsurpassed quality and value for global customers.



**PAS Technologies**

[www.pas-technologies.com](http://www.pas-technologies.com)

Link 329

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### MRO SERVICES

#### Premier Provider of Aftermarket Services

Sargent is a premier provider of aftermarket services for both the commercial & military aviation industries. We offer repair capabilities on more than 20,000 part numbers covering 22 ATA chapters. 24 Hour Customer Support available via [aftermarketsupport@sargentaerospace.com](mailto:aftermarketsupport@sargentaerospace.com). CAAC, ANAC, EASA, FAA.



**Sargent Aerospace & Defense**

[www.sargentaerospace.com](http://www.sargentaerospace.com)

Link 196

### MRO SERVICES

#### An independent provider of aerospace services

StandardAero is one of the world's largest independent providers of engine and airframe maintenance, repair and overhaul, component repair, engineering services, cabin management and paint applications. We serve business aviation, commercial, military, VIP, helicopter and industrial power customers.



**StandardAero**

[www.standardaero.com](http://www.standardaero.com)

Link 443

### MRO SERVICES

#### Repair and Overhaul of GTCP85 and GTCP331 APUs

UAS maintains a pool of APUs & Accessories for exchange to provide immediate delivery. Located just minutes from Charlotte's International Airport, we service a global market daily. With a state of the art test cell, OEM tooling and over 100 years of combined experience, we guarantee top quality.



**Unique Airmotive Services, LLC**

[www.uniqueairmotive.com](http://www.uniqueairmotive.com)

Link 362

### PAINTS/COATINGS

#### Thermal Spray Coatings

High technology coatings improve the performance of products throughout a variety of industries. We provide solutions in the form of thermal spray coating, dry film lubricants, porcelain enamels, and anti-corrosion paints, along with turnkey service to machine and coat a final product.



**Cincinnati Thermal Spray, Inc.**

[www.cts-inc.net](http://www.cts-inc.net)

Link 804

### PAINTS/COATINGS

#### Exceptional Performance from Topcoat to Bottom Line

SKYscapes™ basecoat-clearcoat paint system saves time and money. It cuts up to 30% from your painting process time and eliminates most bake cycles. Plus, it still provides superior appearance and durability, while now being AMS 3095 Certified as a complete chrome hazard-free paint system.



**Sherwin Williams Aerospace**

[www.swaerospace.com](http://www.swaerospace.com)

Link 394

### PARTS SUPPLY/LOGISTICS

#### AVIO-DIEPEN – Your reliable global partner for aircraft parts

Avio-Diepen means reliable service to Operators, MRO's, and OEM customers in more than 100 countries. Our core business is being there with the aircraft parts our customers need, when and where they need them.



**Avio-Diepen**

[www.avio-diepen.com](http://www.avio-diepen.com)

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## PARTS SUPPLY/LOGISTICS

## The most essential tool in an MRO's toolbox!

Subscribers to ILSmart get the following information at their fingertips:

- Reduce Turn-Around-Time
  - Get industry average pricing
  - Send single or multiple RFQs in seconds
  - Reach a market of active buyers when they are ready to buy
- ILS offers multiple ways to streamline your business processes.



**Inventory Locator Service,® LLC**

[www.ILSmart.com](http://www.ILSmart.com)

Link 296

## SOFTWARE

ULTRAMAIN Goes Paperless  
v9 M&E/MRO & EFB Software

Ultramain Systems, Inc. is the only aviation software provider with aircraft M&E/MRO customers running paperless, end-to-end, from the cockpit to the ground.

Solutions cover the aircraft log book, line maintenance, base maintenance, and MRO Operations.



**Ultramain Systems, Inc.**

[www.ultramain.com](http://www.ultramain.com)

Link 230

## STRUCTURAL COMPONENTS

## TIMELY, AFFORDABLE, QUALITY SERVICE

AMI is a full service global resource for maintenance, overhaul, and repair of airframe components and accessories. AMI has two locations: ABQ and FLL. AMI specializes in service on platforms such as Airbus, Boeing, ATR, Embraer, Bombardier, and CRJ's. AMI also provides service on-site worldwide.



**Aero Mechanical Industries**

[www.aero-mechanical.net](http://www.aero-mechanical.net)

Link 845

## STRUCTURAL COMPONENTS

## Engine Nacelle and Fan Reversers

Vertical Aerospace focuses on the repair and overhaul of engine nacelle structures, including nose and fan cowls, fan reversers and exhaust components. We also specialize in flight control surfaces, engine acoustic liners, ducting, and additional airframe structural and related components. (918) 561-5555



**Vertical Aerospace**

[www.goverticalaero.com](http://www.goverticalaero.com)

Link 314

## TEST EQUIPMENT

## 8400K Optical Micrometer Kit

J Chadwick Co provides portable depth measurement systems for inspecting surface damage. When specific tolerances apply, exact measurements are essential. Make "repair or replace?" maintenance decisions with confidence; avoid the use of substandard parts and unnecessary scrapping of serviceable parts.



**J Chadwick Co**

[www.jchadwickco.com](http://www.jchadwickco.com)

Link 720

## TEST EQUIPMENT

## Smaller size. Bigger results.

Our Specialty Flanged Inline Heaters deliver safe, precise, and durable performance, whether for R&D, Quality Testing, or as a key component in OEM equipment. Our standard products offer extreme levels of performance, while our custom models push the limits of technology.



**OSRAM SYLVANIA Inc.**

[www.sylvania.com/airheaters](http://www.sylvania.com/airheaters)



Link 856

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### TEST EQUIPMENT

#### Troubleshooting – Engine to Instrument

The ITS (Instrument Test System) Pod Set, when used with the UxValidator Series II, simulates and measures sensor signals to be displayed on any instrument. With this small and lightweight pod set, testing can be completed on the wing, flight deck, or on the bench without requiring engine run-up.



**ULTRAX Aerospace, Inc.**

[www.ultraxinc.com](http://www.ultraxinc.com)

Link 924

### TOOLS

#### Powerful, Precision Bolting without External Power

High Precision, Mechanical Torque Wrenches & Multipliers

- 1% accuracy - reduced calibration
  - Lightweight - ergonomic, small footprint
  - All-mechanical - no external power required
  - Digital control - International measurement
- A Veteran Owned Company  
[www.ADVANCEDTORQUE.com](http://www.ADVANCEDTORQUE.com)  
 Phone: 860.828.1523



**Advanced Torque Products LLC**

[www.advancedtorque.com](http://www.advancedtorque.com)

Link 303

### TOOLS

#### Portable Videoscope with Joystick Articulation

The new PVRs J provides the quality and advanced features at a price that is easy for the aviation and aerospace professional to afford. The new High Resolution camera system rivals products with a much higher cost. The PVRs J is designed to access the most challenging areas you need to inspect.



**Borescopes R Us**

<http://borescopesrus.com/kits/1-1a-pvrsj-4-1300/>

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# Corrosive Decision



Netherlands Aerospace Laboratories engineers found instances of corrosion on NH90s that deployed to Somalia and the Caribbean.

## Corrosion issue presents a major setback for complex NH90 project

Tony Osborne **London** and **Buckeburg, Germany**

**T**he Dutch government is halting further deliveries of its NH90 naval helicopters until the manufacturer, consortium NHIndustries, can find ways of mitigating a series of corrosion issues.

Engineers from the Netherlands armed forces were concerned to find corrosion on the airframe and moving parts on two NH90 helicopters that had been deployed to the coast of Somalia and the Caribbean during 2013.

An investigation by the Netherlands National Aerospace Laboratories (NLR), at the behest of the defense ministry, found approximately 92 corrosion occurrences on the aircraft—52 caused by insufficient protection, 20 caused by what the NLR termed “wrong material selection,” another 20 attributed to a design flaw, and 14 to wrong manufacturing.

The report, presented to The Hague in May, goes on to list each of the occurrences with images and details of the corrosion.

The delivery suspension, announced by Dutch Defense Minister Jeanine Hennis-Plasschaert on June 27, will take effect in September when the Netherlands was due to receive its 14th aircraft, leaving seven to be delivered.

This marks a significant setback for the complex NH90 program, which had appeared to have put many of its difficulties behind it with a ramp-up in pro-

duction and increased availability and customer deliveries of aircraft in the fully operational configuration (FOC).

In a letter to the Dutch Parliament, Hennis-Plasschaert said that corrosion and wear found on the aircraft were much greater than would have been expected given the age of the helicopters and the number of flight hours they had completed. The NLR report focused on the two aircraft deployed; N227, in the interim meaningful operational capability configuration (MOC), which had been sent to Somalia; and FOC aircraft, N233, that had been deployed to the Caribbean.

According to the NLR, differences between the MOC and FOC versions include, among others, the intermediate gearbox housing, which is composed of aluminum in the MOC and magnesium in the FOC, as well as differences to the nose landing gear and several of the avionics systems.

“The FOC version is supposed to be better suited for operations in saline environment but comparison of the corrosion found on the N227 (MOC) and the N233 (FOC) shows that both versions are equally sensitive to corrosion,” the report states.

“Salt deposits are generally found in locations where humid air enters the helicopter during operation. However, some of the deposits are found in locations where the salt must have been

deposited during rinsing operations, by drying of run-off waters or by air circulation that was unforeseen.”

The report further states that some components on N233 had been protected against corrosion before its mission to the Caribbean and although this had prevented corrosion on the protected components, it resulted in corrosion on some of the components next to the protected ones.

NHIndustries says it has developed technical solutions for 60% of the problems found in the report and in the fall will report on the progress of its plan to deal with the rest. But The Hague has decided to postpone deliveries anyway, a move that will have a negative impact on Netherlands helicopter operations for at least two years. Officials still plan to send the NH90 to support the country's commitments off the coast of Somalia, but missions in the Caribbean with the NH90 are on hold until 2017; instead the land-based AS535 Cougar helicopter will be used—it is a type the NH90 had been due to replace. Eight of the Cougars will now remain in service until 2018 at a cost of €8.9 million (\$12.17 million) a year.

With the advent of the most recent glitches, officials believe there will not be enough technicians and pilots trained on NH90 to support full maritime missions until 2019.

“I appreciate the efforts of Nahema [the NATO helicopter management agency] and the manufacturer, and I believe that they are working very seriously to solve the problems. At this time, however, there is no complete picture yet,” said Hennis-Plasschaert. “There are short-term, good steps forward and I am confident the manufacturer can fix the problems and the helicopters can improve.”

The news comes just days after the NHIndustries consortium delivered the 200th aircraft to the Belgian armed forces at a ceremony in Buckeburg, Germany, where representatives of most of the nations flying the aircraft were meeting at the NH90 Users Conference. The entire NH90 fleet has now chalked up 50,000 flight hours and the consortium is in negotiations with Qatar following that country's selection of the NH90 as its new battlefield and naval helicopter at the end of March.

Doha plans to purchase 22 NH90s, 12 in the TTH configuration, and 10 of the naval version. Deliveries could begin in 2017. ☼

# Prospering in Tough Times

*Thirteen years into its development, Lockheed Martin's crown jewel—the tri-service, stealthy F-35 Joint Strike Fighter—is finally making its international debut. The single-engine fighter is flying at the Royal International Air Tattoo and Farnborough air shows outside London. Before heading across the Atlantic, Lockheed Martin Chairman, President and CEO Marillyn Hewson sat down outside Washington with AW&ST Editor-in-Chief Joseph C. Anselmo and Senior Pentagon Editor Amy Butler to talk about the issues facing the company and its programs.*

**AW&ST: What are some of the most profound lessons for Lockheed Martin emerging from the F-35 experience?**

**Hewson:** This is a brand-new program that brings with it a lot of complexity—uniqueness in development, the program itself and the capability, coupled with three joint services and eight international partners. It is different from any program we've ever had. So the lessons learned are to make sure we have strong communication, fully understand requirements and are working through the process. Another important lesson is that it is about performance. We have got to get through a complex development program, ramp up production, get through the sustainment phase and then perform throughout.

**How is Lockheed Martin infusing those lessons into future campaigns?**

Program managers undergo very structured training. Our focus is on our customer. I've stepped up the discussion to answer the questions: "Are we listening and are we responding? Are we really understanding the objectives of our customer as well as we should be?" But that is something that's part of our business anyway. Have I put an additional priority on it? Yes. I think it's critical to have open, transparent communications with our customer and that we are listening so we can meet their requirements and truly adjust to their needs.

**Years before you were CEO, former Pentagon acquisition chief Ashton Carter said the perception in the government was that Lockheed Martin's JSF program**

**manager would be fired if the company's award fee went below a certain threshold. How do you benchmark the success of your program managers, and was that kind of mentality in that era a lesson going forward for the F-35 and other programs?**

I can't really speak to the experience you described. We rebased the program in 2010 and have done very well since then. We expect our program managers to really understand the requirements, stay close to the customer in terms of changes that might be occurring and perform on cost, schedule quality and technical. And that goes all the way through the supply base. If it results in some return—whether it's an award fee, incentives, or similar things—that's just secondary to meeting the objectives.

**Since you've become CEO, Lockheed Martin's stock has risen more than 85 percent—triple the performance of the Dow Jones Industrial Average. How do you explain those results when the defense market is in a downturn?**

It's due to the performance of our team. Our sales are down, although not as much as we anticipated. Our earnings per share and margins have increased, primarily because we are performing on programs. We have something like 6,000 programs that we're managing on a day-to-day basis, and I've never seen us performing better. Our portfolio is very strong, and we are continuing to invest to keep it relevant. Our leadership team has been through ups and downs, they know how to manage through a down cycle and take advantage of an up cycle. That is what we're doing—addressing

affordability and making sure we have the right business structure in place.

**Would you characterize this as a cyclical downturn in defense, or are we in a structural downturn because of all the pressure on costs?**

This downturn is different. If you look back to the late 1980s-early 1990s downturn, we were coming off the [President Ronald] Reagan buildup, where we had made significant investments in defense. So when we had the "peace dividend," we didn't have to recapitalize as much, nor did we have the structural issues of the global financial meltdown we experienced in late 2008 and beyond. Now we are coming off of two wars and seeing a decline in need. But what hasn't gone away is the intensity of global tensions,



Marillyn Hewson talks with Chris Meyer, deputy program manager of the Harvest Hawk program, during a delivery ceremony at Lockheed Martin Skunk Works.

which keep spiking. That, coupled with budget pressures, makes this a different environment.

**Arati Prabhakar, director of the Defense Advanced Research Projects Agency (Darpa), laments the cost and time it takes to procure major weapons systems, and the inability to infuse commercial technologies into them during development. Do you agree that this is a threat to national security?**

I believe that if we don't invest now we will create a gap from which you can't recover. So as a nation, you have to stay on top of maintaining techno-

logical superiority and investing in new capabilities. You can't just take a pause and think you can catch up. You've got to keep investing [in R&D], just like we are doing in our business. That's the lifeblood of our company. Technological development and innovation are what customers come to us for. We can't stagnate. The same thing applies to national security.

**Prabhakar was going beyond investment. She is saying the system is too slow, too inflexible and too costly in terms of development of systems.**

Hopefully she is in a position to work with everybody else to streamline that. Darpa does a really good job of helping to spur incubator-type hard problems, or quick-turn-type problems. So that is a good model for streamlining. We

## Marillyn Hewson

Age: 60

**Education:** Bachelor of Business Administration and Master of Arts degrees from the University of Alabama.

**Career:** Joined the Lockheed Corp. in 1983 as a senior industrial engineer, and rose through 19 management positions before taking the top job on Jan. 1, 2013.

look at the Skunk Works as another model. Many companies and organizations have asked, 'How are you able to innovate so quickly?'

**You say Lockheed Martin's investment in IRAD (independent research and development) is going up, but as a percentage of revenues isn't it below historical norms? It was just 1.5 percent of your revenues last year.**

I don't think it is below historical norms. You've got to look at R&D dollars much more holistically than just IRAD. We have a lot invested on the front end of development programs where we share the development cost. I don't think we are down.

**What are some near-term opportunities where you can use IRAD in campaigns, or even to help**

**make unsolicited proposals to the government?**

We are focused on some specific things I cannot tell you about now—which we see as near-term opportunities to help grow the business. As for the longer-term, we are putting an effort into hypersonics, directed energy, autonomy and robotics, and advanced materials like nanotechnology, 3-D printing and advanced manufacturing. Those are areas we see as potential game changers.

**The U.S. Navy's Uclass (Unmanned Carrier-Launched Airborne Surveillance and Strike) requirements seem to de-emphasize stealth. If they remain as they are, is it possible that Lockheed Martin would decide not to bid?**

We'll have to see how it all comes out in terms of the requirements. Our Skunk Works team has done a superb job working on the preliminary design efforts. We hope that it will line up with what the U.S. government wants. We've been engaged in it for some time now. We will have to assess it very closely and determine what we will do. We go through a very disciplined approach [to decide] a bid or no-bid. Of course, we are going to pursue opportunities we think we can win.

**Russia says it will stop selling the RD-180 rocket engine to the U.S. If a new engine doesn't materialize in the next couple of years—and the Atlas V launcher is at a stand-down—does it make sense for Lockheed Martin to stay in the United Launch Alliance (ULA) joint venture with Boeing?**

There is about two years' worth of Atlas inventory, plus you have the Delta IV and the ability to adjust your launch manifest. So I think that is the near-term answer to your question. No one knows if [launch services are] going to stop after that—it's early days yet. Will there be an opportunity for another engine? Potentially, and we would support whatever the U.S. government wants to pursue in investing in another engine.

**Has Lockheed started to think about life after Delta IV, given that SpaceX is aiming to disrupt the market? It is changing the pricing**

**structure, and perhaps customer expectations as well.**

If SpaceX gets qualified and makes it through the certification process, we certainly are prepared to compete with them. We have a great track record—83 successful launches out of ULA, 115 or so on Atlas itself—going back to when it was a Lockheed Martin-only product. We are constantly assessing what the competition will look like in the future. I think our price is pretty competitive. They have to achieve certification and be reliable—we'll see how their pricing comes out. In the meantime, our job is to continue to provide affordable launch capability, which is what we're doing with ULA.

**Your predecessor, Bob Stevens, used to liken cyber to the "Wild West." How far along is Lockheed Martin in developing a significant revenue stream in that area?**

Cyber is an approximately \$1 billion business for us today, and we expect to continue to grow our cybersecurity capability, both domestically and internationally. We are helping a lot of governments in that area, as well as large commercial companies. It is small relative to our size as a \$45 billion company, but you have to recognize that cybersecurity is embedded in a lot of the programs that we have as well.

**Are [Russian President] Vladimir Putin's actions in Ukraine making Eastern Europe a more attractive market to Lockheed Martin?**

There is certainly a big interest in that region for missile defense and additional capabilities. We are pursuing the Poland shield, where they are going to spend \$5 billion on an air defense system. We have MEADS [Medium Extended Air-Defense System] as our offering. I've had discussions in the region with Germany, Italy and Poland, who are very interested in MEADS as a modern, very capable, 360-degree capability that I think gives them the ability to meet their needs. It is NATO-interoperable so it potentially could even be a NATO system. There continues to be interest in other of our products as well. Everywhere in the world, where there's a demand for our products, we're there to share the capabilities we can provide. ☼

# Helicopter, Rescued

Combat Rescue Helicopter to benefit from maturity, scale of Sikorsky's UH-60M program

Graham Warwick **Washington**

**W**hen the U.S. Air Force's CSAR-X combat search-and-rescue helicopter program was canceled in 2009, it was just another in a multibillion-dollar series of Pentagon procurement mistakes that included the KC-X aerial refueling tanker and VXX presidential helicopter.

But in each case the military requirements remained unfulfilled and reemerged in new competitions with tightly constrained specifications designed to avoid the protests and overruns that doomed the original programs.

time around, Sikorsky this time was the only bidder.

This was to be repeated when the Air Force launched the Combat Rescue Helicopter (CRH) program to replace the canceled CSAR-X. Credit for exceeding the tightly circumscribed requirements was scant. Once the request for proposals was released in 2013, Boeing, which had won CSAR-X in 2006 with the heavy HH-47 Chinook, declined to bid. So did Northrop Grumman (teamed with AgustaWestland) and EADS (now Airbus).

So Sikorsky, now teamed with for-

president of defense systems and services. "At the time, we submitted a bid with the full expectation of competition. We had no indication if our competitors were in or out, so we submitted with the idea of a full competition. Our price reflects that," he says, adding that the bid was "hundreds of millions of dollars" under the Air Force's acquisition cost target.

CRH-60s will be built as standard UH-60Ms, then modified at Sikorsky with increased internal fuel capacity, a reconfigured cabin, in-flight refueling probe and other structural enhancements. Aircraft will then be sent to Lockheed Martin for installation of the mission systems, including enhanced cockpit displays and offensive systems. Helicopters will return to Sikorsky for finishing and delivery. A similar approach to building and modifying S-92As is planned for the VXX.

The CRH contract covers four test

aircraft and seven aircrew and maintainer training systems—Sikorsky and Lockheed are to provide the training for the Air Force, Mehta says. Five low-rate initial production aircraft are to be delivered in 2020. The 112 helicopters planned will replace aging HH-60G Pave Hawks. Although it is a stand-alone contract and not part of Sikorsky's UH-60M multiyear procurement deal with the Army, the

CRH-60's price "reflects the economies of scale," he says.

The parallel VXX and CRH EMD programs, alongside development of a version of the Black Hawk for Turkey, will cause a spike in the engineering workload at Sikorsky, but Mehta says the company has "significant capacity." Development work on the CH-53K for the Marine Corps and CH-148 for Canada "is on the down slope," he says, freeing up engineers to work on the VXX and CRH. "We are also leveraging our partnerships. Sikorsky is not doing all the work; Lockheed Martin is doing the mission systems on both programs," Mehta says. ☐

**The combat rescue CRH-60 will be a UH-60M with more fuel capacity, inflight refueling capability and new defensive and offensive systems.**

KC-X Round 2 in 2010-11 was a restaging of the original 2007-08 Boeing-versus-Airbus contest, but this time Boeing's 767-based KC-46 was selected. The rules had been rewritten to provide only limited credit for exceeding the requirements, making the larger Airbus A330-based KC-45 less attractive.

After the requirements runaway that killed the original program in 2009, the U.S. Navy took a similar approach of strictly limiting the specifications when it restaged the VXX competition in 2012—with a similar, if more dramatic, reversal as the result. Beaten by Lockheed Martin with the larger AgustaWestland AW101 the first

mer VXX and CSAR-X rival Lockheed Martin, finds itself in possession of fixed-price incentive contracts for two programs for which it was the only bidder. The Navy awarded the company \$1.24 billion in May for engineering and manufacturing development (EMD) of the VXX, based on the commercial S-92. In June, Sikorsky received \$1.28 billion for EMD of the CRH, based on the UH-60M Black Hawk. The VXX program is to total 23 aircraft; the CRH will total 112 aircraft for a value of \$7.9 billion.

Sikorsky insists it did not get a free ride to the CRH. "Our proposal was very competitive," says Samir Mehta,

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# Fighting Back

## Modernizing Europe's premier combat aircraft

Bill Sweetman **Washington**

**L**ate last year, Lockheed Martin was still showing a chart to potential industrial partners that depicted all the so-called fourth-generation fighters going out of production well before 2020 and leaving the F-35 with a Western-world monopoly. That script is not playing out as written.

Within the past few months, the Saab JAS 39E program has been underpinned by Brazil, whose initial order of 36 aircraft will be followed later by two more orders of the same size. With Russia, its traditional adversary, behaving badly in Ukraine, Sweden has raised its commitment to the program, lifting orders to 70 from 60 and abandoning the vestiges of the original plan to convert JAS 39Cs to the new version. This in turn has given Saab more opportunity to offer leased JAS 39C/Ds on the export market.

At the same time, the JAS 39E has emerged as a new aircraft sharing little more than a basic configuration with the earlier version, but—at least as planned—costing less to acquire and operate.

In January, France committed to another upgrade of Rafale, and although negotiations with India continue to grind forward at less-than-war speed, even its Eurofighter rivals concede that Dassault has the inside track in Qatar—as many as 36 aircraft in a first



**Tap the Icon** in the digital edition of *AW&ST* for an interactive look at the Dassault Rafale in a heavyweight configuration, or go to [AviationWeek.com/Rafale](http://AviationWeek.com/Rafale)



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batch and more to follow—and the United Arab Emirates' requirement remains active, following its expulsion of Eurofighter at the end of 2013.

Eurofighter itself has hit a rough patch, although team members are casting hungry eyes on India should the Rafale deal go awry. However, an important milestone is coming up in the form of the U.K.'s strategic defense review next year, which should address the thorny question of how many F-35s the nation will actually acquire and (consequently) the degree to which the F-35 force can take over the missions of the Tornado. A similar process is occurring in Italy.

The Gripen is now certain to remain in production into the 2020s, alongside either Rafale or Typhoon or both. The delayed demise of the European fighter industry is due to several factors. Nations that are not yet approved to receive the F-35 constitute a substantial market. There are also nations that cannot afford it at its current price.

However, the upgrades to the Euro-



**Eurofighter Typhoons and Dassault Rafales are in formation near France's Saint-Dizier air base.**

## Europe's Fighters

| Type           | Orders | Delivered/<br>Backlog | Last<br>Contracted<br>Delivery | Sales Prospects                                                                                    | Next Upgrade IOC | Main Improvements Included                                                                                                                          |
|----------------|--------|-----------------------|--------------------------------|----------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>GRIPEN</b>  | 312    | 240/72                | 2026                           | Brazil (36-100, first batch in negotiation)<br>Denmark (30, competition)<br>Malaysia (competition) | 2018             | Revised and enlarged JAS 39E with F414 engine, AESA and new electronic warfare system; Meteor and Taurus cruise missile to be introduced on JAS 39C |
| <b>RAFALE</b>  | 180    | 130/50                | 2017-19                        | India (126, in negotiation)<br>Qatar (36, evaluation)<br>Malaysia (competition)                    | 2018             | F3-R with new targeting pod, improved laser-guided weapon functions and Meteor AAM                                                                  |
| <b>TYPHOON</b> | 571    | 400/171               | 2017-18                        | Denmark (30, competition)<br>Malaysia (competition)                                                | 2017-19          | Meteor AAM, Storm Shadow & Taurus cruise missiles, AESA                                                                                             |

IOC= Initial Operating Capacity

Sources: Manufacturer and government data

pean fighters underscore the fact that it was always simplistic to lump them into the same category as older U.S. and Russian designs. In various ways they are a class unto themselves, with a degree of automation and sensor fusion that allows them to grow into true multi-role platforms; capable and fully integrated electronic-warfare systems; and individual strong points such as

the Rafale's range, the Typhoon's supersonic cruise and agility and the Gripen's low costs and networking.

The past year has also seen progress with the Neuron unmanned combat air vehicle (UCAV), the unveiling of BAE Systems' Taranis and Anglo-French convergence on a joint program. On the French side, the UCAV is not seen as a replacement for the classic fighter

,with its panoply of bolt-on weapons and mission systems, but as a complement to it: a highly stealthy vehicle for the toughest targets, including large surface-to-air missiles, enabling the fighter to do its job. Rafale, Dassault says, will be around until 2050; the Swedes plan on Gripen until 2040. Some of the plans that support that goal are detailed in the next few pages.

# Choose Your Weapon

Fighters rearm for the 2020s and beyond

Bill Sweetman **Paris** and Angus Batey **London**

**T**he crown jewel of Europe's fighter weapon industry—and the only new weapon currently undergoing integration of all three European fighters—is MBDA's Meteor ramjet-powered air-to-air missile. It is the world's first air-breathing AAM and, Aviation Week understands from industry sources, has already reached the stage of a contingency operational capability with Sweden's JAS 39C/D Gripen, which is due to be fully operational with Meteor next year. "We have no further work to do on Gripen integration," an MBDA executive says.

Meteor has had a long development process and has been criticized for its high cost, but the four Eurofighter nations—Germany, Italy, Spain and the U.K.—along with France and Sweden) have now ordered the missile and MBDA has an order backlog in four digits.

On the Typhoon, the goal is to have Meteor ready for service in 2017. Software to permit an initial integration will form part of the P2E (Phase 2 Enhancements) package, with full integration achieved in the follow-up software program, P3E, which is being developed at BAE Systems' Warton plant. The P2 and P3 enhancements will permit full integration of Meteor with both the future active, electronically scanned array (AESA) radar and the current mechanically scanned Captor. Meteor will therefore be available to both Tranche 2 and Tranche 3 Typhoons, even though only the latter will be able to field AESA.

Rafale's F3-R standard, under contract since January and due for service entry in 2018, provides for two Meteors on the aft body weapon stations. Technically the aircraft could carry more than that, Dassault says, but so far that is all the French customer has requested.

The Meteor development program is through, with MBDA continuing to support Rafale and Typhoon integra-

**Saab's Gripen Demo is carrying Meteor air-to-air missiles, which will be fully operational on Swedish AF JAS 39Cs next year.**

tion. "Pilots are saying that when we take it into service, we'll have to redo all our fighter tactics," the MBDA executive says. The company continues to say that against an agile, evading target, Meteor's no-escape zone—the area within which, if a missile is launched, the target cannot kinematically avoid being hit—is three times larger than that of a conventional single-pulse rocket weapon in a head-on engagement, and five times larger in a tail-chase.

The key is the ramjet engine, which is not only more efficient than a rocket but can also be throttled: the burn rate of the boron-based sustainer propellant is determined by pressure, so can be controlled by a valve between the propellant container and the ramjet duct. This process is controlled by Meteor's guidance system: After the boost phase, the missile reaches a set cruise speed, but then accelerates as the target gets closer. "The goal is to convert all the fuel into speed at target impact, but not before," Aviation Week is told.

Typhoon and Gripen are both to be fitted with precision cruise missiles. In the latter case, Sweden's expanded defense budget—a response to Russia's activities in Ukraine—includes the purchase and operational integration of the Swedish-German Taurus KEPD 350, while the U.K. is now moving forward with Storm Shadow integration as the retirement of Tornado moves closer.

Storm Shadow integration work is progressing in flight tests in Germany and Italy. Flight testing takes into account that Germany operates a similar,

but not identical, Taurus missile. Integration is part of P2E and an in-service date in the 2015-16 range is anticipated.

"Those trials have gone really, really well," says Andy Lumb, BAE's head of Typhoon weapons systems architecture. "We have taken some of the worry away from aerodynamics now and refocused into the avionics integration, to make sure we can get the mission-planning integration into the weapon and the aircraft, and get ready for the weapon-release side of it."

Another new weapon proposed for Typhoon is the low-collateral-damage, moving-target MBDA Brimstone 2, the follow-on to the Dual-Mode Brimstone missile, which was procured from MBDA under an urgent operational requirement and arms Royal Air Force (RAF) Tornados. Official confirmation of a study program was not made until June 19, although a contract was agreed to early this year and BAE began work in February. Part of the funding is coming from the U.K. defense ministry, with the rest provided internally by BAE, which sees Brimstone 2 integration as a help to future export sales.

During a visit to Warton, Aviation Week was shown a photograph of a 1/12-scale wind-tunnel model of a Typhoon carrying four Brimstone launchers; each launcher is equipped with three missiles. In art released with the official announcement last month, the aircraft is shown with two launchers.

SAAB

The company's position is that it intends to provide a capability for Typhoon to carry a minimum of six Brimstones.

"We're looking at the aerodynamics of putting it onto the jet, and [assessing] the impacts on the flight-control system and the armament control," Lumb says. "The launcher conforms to a standard interface, so there are no worries in terms of interface standard. For Typhoon, because it is highly agile, we just have to worry about having, effectively, two big crates on the outboard wings, in terms of what that does to the aerodynamic performance."

The assessment phase is expected to run until late this year. Lumb estimates that an integration program would be completed before Tornado is retired from the RAF in 2019.

Integration of the follow-on capability to Brimstone, a requirement the British defense ministry calls Spear 3, which is expected to be met by a new MBDA-developed missile, is also a possibility. "Spear 3 is still in its design phase, so we're still waiting for lines and commitments from MBDA in terms of what the weapon looks like overall," says Lumb. "Brimstone's a short-range, close-air-support type of weapon, whereas Spear is aimed at a far longer-range capability; Brimstone is rail-launched while Spear is eject-launched. But both Brimstone and Spear have a route to integration on Typhoon, and we would like to realize either of those weapons onto the aircraft: It is just that the RAF's primary platform for Spear 3 currently is F-35."

Rafale already carries a wider range of weapons than its European rivals. The F3-R program brings on the Thales PDL-NG next-generation laser-designation pod, replacing the current Damocles. With high-definition sensors and better display formats, including a picture-in-picture mode, and in conjunction with new software, the PDL-NG is intended to exploit the full envelope of the laser-guided version of the Sagem Hammer bomb family. PDL-NG also will be able to lase the target automatically when necessary, even after the bomb's long flight time. The pilot's ability to select different trajectories (such as vertical impacts) and fuze modes will be improved as well. ☼

# Spectral Feast

## Europe revamps fighter systems and sensors



**Bill Sweetman** *Washington*, **Angus Batey** *London* and **Amy Svitak** *Paris*

**M**odernizing electronics is the most efficient way to upgrade a fighter design, and European governments and industry are investing in those areas to keep their programs competitive.

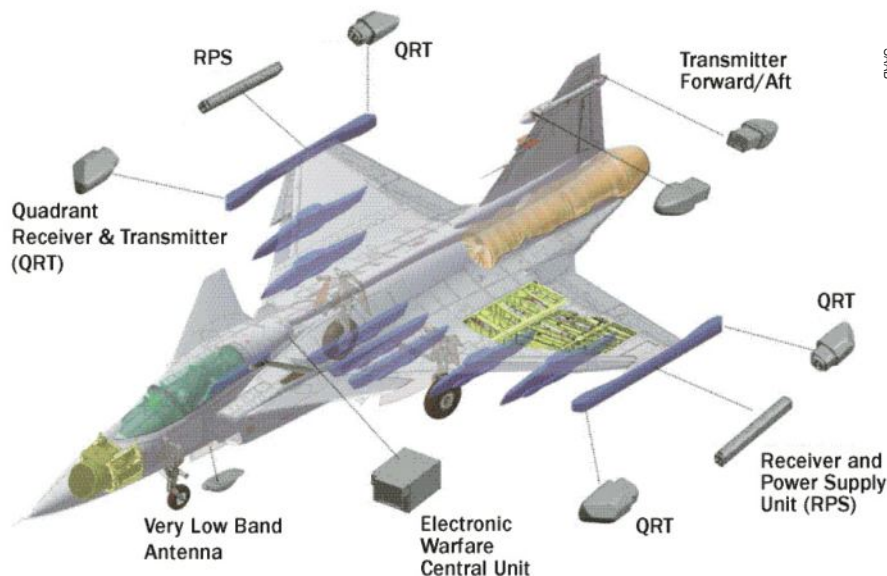
The most comprehensive fighter avionics program in Europe is the all-new sensor and processing suite for the Saab JAS 39E Gripen. Its main components are the Selex Raven ES-05 active, electronically scanned array (AESA) radar and Skyward-G infrared search and track (IRST) sensor (*AW&ST* March 17, p. 28) and Saab's all-new electronic warfare system (*AW&ST* May 26/June 2, p. 66), including AESA transmit/receive units using gallium-nitride (GaN) technology.

Selex asserts that its IRST technology—also used on Typhoon—has detected and tracked stealth aircraft and can do so at tactically useful ranges. The Raven radar will be the first opera-

**The Rafale's new DDM-NG imaging infrared missile-warning system uses hemispherical "fisheye" optics.**

tional AESA to use a "repositioner"—a rotating mount for the canted array, which provides a wider field of regard than a fixed AESA. The jamming system—which is regarded as a major technological advance and will not be fully installed before 2023—will be able to generate high-powered, agile jamming beams over a wide spectrum.

Saab also is building on its experience with datalinks to improve the already close connections that are possible within a flight of Gripens. This will include the ability of one aircraft to jam the target while the other tracks it, automated and unpredictable "hopping" of the radar transmission from one aircraft in the formation to another, and the use of multiple IRSTs for high-accuracy passive ranging and tracking.



SAAB

### Redesigned wingtip pods carry much of the JAS 39E's new electronic-warfare system, including AESA jamming units.

France has also announced big investments for Rafale. Dassault has already inducted the first of the French Navy Rafale F1-standard aircraft to begin an upgrade to the latest service configuration, F3-04T, which includes the active, electronically scanned array (AESA) version of the RBE2 radar and the DDM-NG missile-warning system. The program goal is to retain all the aircraft in service through rolling upgrades, the company says.

The DDM-NG, part of the Thales/MBDA Spectra defensive avionics suite, comprises two imaging infrared sensors located on either side of the fighter's fin-tip pod, each with a hemispherical field of view and jointly providing full spherical coverage other than the area blanked by the fighter's wing. Its ability to detect and track other targets, such as aircraft, is classified, according to Dassault.

In January, the French defense ministry awarded Dassault a contract for the next major Rafale upgrade, known as F3-R. It includes more powerful processors and upgrades to the Multifunctional Information Distribution System-Low Volume Terminal datalink and the automatic ground collision avoidance system.

For tactical and strategic reconnaissance missions, F3-R will include in-cockpit replay and analysis of imagery from the Thales Areos long-range oblique photography (Lorop) reconnaissance pod. The Rafale pilot or weapon system operator will be able to review imagery without inter-

rupting the pod's collection process.

The upgrade will also see a series of improvements to Spectra. Developed by Thales and MBDA, Spectra is a fully automated system that provides electromagnetic detection, laser and missile warning, jamming and four chaff/flare dispensers. French industry sources say that during operations over Libya in 2011, Rafale literally disappeared from the radar screens of the Libyan air force, performing "soft kills" on enemy radar systems.

Bruno Carrara, director of the Rafale program at Thales, says the F3-R upgrade will involve a more advanced electromagnetic detection capability based on new digital wide-band-receiver technologies, improving the suite's spectrum analysis as well as its instantaneous interception capability.

Thales will also update Spectra's solid-state jamming subsystem, which was one of the first to use electronically steered phased-array antennas. Carrara says for F3R, Spectra will include more powerful antennas, while further increasing the power supply so that more threats can be jammed simultaneously. Like Saab, Thales will use GaN technology because of its power and efficiency.

Since the late 1990s, Spectra's designers have dropped hints that the system can perform "active cancellation"—receiving a radar signal and mimicking the aircraft's echo exactly one-half wavelength out of phase so the radar sees nothing. Carrara again implies that such a capability is in

use: "There are other strategies, such as generating signals that will encompass or be higher than the echo from the aircraft, so that the radar threat will receive a signal that will mask the echo from the aircraft," Carrara says. "Instead of creating a false echo and drawing the radar to the wrong place, the idea is to produce a signal that will mask the echo of the aircraft, so the radar will be unable to detect the aircraft Spectra is protecting."

So far, the Eurofighter Typhoon appears to be running third in the AESA race. This summer, the last Tranche 2 aircraft will be completed. Its successor, Tranche 3 provisions Typhoon for the AESA and adds enhanced on-board computing and additional fiber-optic cabling and video capability. "But a blindfolded pilot getting in there won't even see an additional switch," says BAE's chief test pilot, Mark Bowman. "For a pilot jumping from a Tranche 2 to a Tranche 3 aircraft there is that high level of concurrency."

It is now a firm part of Royal Air Force planning that Tranche 1 Typhoons will be retired in 2019. For Tranche 2 and 3 jets, though, the focus is on software upgrades. The Phase 1 Enhancements (P1E) program has been split into two parts—P1E-A and P1E-B. The P1E-A product provides the aircraft with a basic set of air-to-ground capabilities, which P1E-B builds on (for example, it is via P1E-B that Typhoon gains a full capability with the Paveway IV weapon).

"The software product isn't determined by whether it is a Tranche 2 or Tranche 3 aircraft," Bowman explains. "We've completed all the flying on P1E-A, which is in service with the RAF and the Royal Saudi Air Force. And we've finished the P1E-B product now and aircraft are entering into service ahead of the U.K.'s requirement of April 1, 2015. Next up is P2E (Phase 2 Enhancements), which brings significant differences in HMI (Human-Machine Interface) such as better integration of the helmet, and so on."

This supports the multirole capabilities of the aircraft. "One of Typhoon's benefits, and a discriminator over other platforms out there at the moment, is the fact it can do air-to-air and air-to-surface at the same time," Bowman continues. "Where P2 takes it is to build even more on those philosophies, and [provisions for] introduction of new weaponry." ☐

# Typhoon Rising



## U.K. sets course for Typhoon ground-attack capability

**Tony Osborne** **London**

**O**n April 1, 2015, the U.K. Royal Air Force will stand up its fifth front-line squadron of Eurofighter Typhoons.

The reformation of II (Army Cooperation) Sqdn. at RAF Lossiemouth in Scotland will not only round off the U.K.'s deployment plans but will also mark the moment that the RAF declares its Typhoon force a truly multirole asset.

It has probably taken longer than the RAF anticipated; the Typhoon has been in service now for 11 years. But the addition of Phase 1 Enhancement (PIE) capability on the Tranche 2 fleet should help pave the way for the Typhoon to take on more of the ground-attack mission currently held by the Panavia Tornado GR4 force, which is due to retire before the end of this decade.

The addition of the PIE delivers a ground-attack capability with the U.K.'s primary precision-guided weapon, the Raytheon Paveway IV, along with a host of other improvements.

But if Typhoon is going to take on the role of the RAF's big stick before the end of the decade, the GR4's other weapons—such as the MBDA Storm Shadow cruise missile and the Brimstone, direct-fire air-to-ground missile—also need to be integrated to

ensure there are no gaps in the RAF's strike capability.

"Tornado will be the mainstay of our ability to conduct long-range strategic strike using Storm Shadow," says Air Vice Marshal Gary Waterfall, the former U.K. Typhoon Force Commander, in a recent interview with Aviation Week. Waterfall is now Air Officer Commanding No. 1 Group.

"We have got until 2019, to [ensure] a correctly trained, configured and prepared force with Typhoon, with Storm Shadow and Brimstone to enable us to do that heavy lifting once it [Tornado] goes.

"I am convinced it is possible, [and] we are working with MBDA and Eurofighter to deliver it."

"I need them [Storm Shadow and Brimstone] in 2018, as that gives me a 12-month period to enable us to replace the Tornado contribution," adds Waterfall.

The Eurofighter consortia partners began Storm Shadow flight trials late last year, and in mid-June BAE Systems was awarded a £5 million (\$8.5 million) contract to study how the Brimstone II could be integrated, a program that aims to create a common launcher system that could also drop the future Selective Precision Effects at Range (Spear) 3 networked precision-guided weapon, which the defense

ministry is also said to be considering. Currently, Spear III is slated only for the F-35.

But integration of new weapons is both complex and expensive. New weapon shapes require changes to the

**BAE Systems flew the first Tranche 3 Typhoon in December, and the type looks set to be in service through 2030 and beyond.**

aircraft flight-control and armament systems.

Anything we can do to replicate the size and fit of an original pod makes the integration process much cheaper, explains Waterfall.

Raytheon is working on a series of upgrades and new capabilities for Paveway IV that follow this rule. The company is introducing a new low-collateral damage warhead and penetrator capability that does not affect the weapon weight or its aerodynamics.

Typhoon already has proved itself to be effective when it comes to ground attacks. Over Libya, modified Tranche 1 aircraft were able to drop the 1,000-lb. GBU-12 Paveway II laser-guided bomb on targets, mitigating some of the risk of collateral damage. With the addition of Paveway IV however, Typhoon will be able to drop munitions on targets in high-risk settings such as urban areas, because pilots will be able to set the weapon to explode above or beneath a target or hit it at a set arrival angle.

"This is the dawning of a precision-attack capability for Typhoon," adds Waterfall.

Approximately a dozen Typhoons are now flying with the PIE software, and the RAF plans to test the capability early next year with a deployment to the Red Flag exercise at Nellis AFB, Nevada.

The RAF has now taken delivery of most of its Tranche 2 Typhoons and is getting ready to accept the first Tranche 3 aircraft, the first of which rolled off the BAE Systems production line at Warton, Lancashire, late last year. But the RAF is in no hurry to receive the Tranche 3 aircraft, especially as these, along with the Tranche 2 fleet will become the mainstay of the Typhoon fleet until the current planned out-of-service date of 2030.

The Tranche 3 Typhoon, the first example of which was flown by BAE Systems in December 2013, features

increased avionics computing and electrical power and capacity, fuel-dump capability and provisions for an active, electronically scanned array (AESA) radar.

"We have to wait for the formal clearances to fly, but there are finite resources do that," says Waterfall.

"I have to think what else could I clear with those resources, and I want to make sure I can deliver on my multi-role capability on Tranche 2," he notes.

Early Tranche 1 aircraft, however, are unlikely to see service beyond

the Tranche 3 jets more affordable for the RAF.

The consortia consider AESA, or e-scan radar as it better known in Europe, to be a key component. Euro-fighter remains hopeful of achieving an agreement on the e-scan radar between the partner nations—Germany, Italy and Spain—during the summer. The RAF sees the radar as critical to keeping the aircraft relevant during the 2020s. Recent defense ministry documents, which are related to its major projects portfolio, cite that a

efficiently utilize its limited training time and flying hours as it faces airspace constraints, high operational costs and the need to learn how to fly in large-scale operations.

"We have been going through a revolution in synthetic training and realizing that if we want to be good at our game, then a lot of the time we are going to derive the most benefit from flying in the simulator than in the air.

"To go out and employ the large formations that we need in order to train is becoming more difficult as the aircraft and missiles become increasingly complex and demand increasing amounts of airspace to train effectively, which is why we are exporting that training into the synthetic domain."

Currently, front-line Typhoon squadrons receive about 25% of their training in the simulator, compared with the more favorable 65% by the

**Tranche 1 Typhoons remain the backbone of the front-line squadrons and are usually the first to be deployed.**

Typhoon operational conversion unit, 29 Sqdn. But the force wants the front-line numbers closer to that of the U.K. F-35 force's, which is expected to have a 50:50 ratio of flying hours to simulator hours for pilots when the type is introduced in the coming years.

As part of this investment, the force is looking to expand its number of simulators. Currently there are four Typhoon-related simulators at Coningsby and two at Leuchars, Scotland. The Scotland-based ones will move to Lossiemouth in the near future because Leuchars is being restructured as a British Army base this year. All four simulators at Coningsby can be linked. The plan is to install four more simulators—two in Scotland and two at Coningsby—with the four already in place, and link them all so joint training can be carried out from both bases.

The U.K. has a clear plan for its Typhoon fleet, and fellow partner Italy is increasingly seeing the potential for Typhoon as a ground-attack platform.

"We are on a journey with Typhoon that is not going to finish until the 2020s, and even then we won't look back and rest on our laurels in 2023 and say, 'look at that great aircraft, it's all finished now.'"

"I'd be surprised if it wasn't still in service beyond 2030," says Waterfall. ☛



TONY OSBORNE/AW&ST

2020. While the aircraft have proved useful in testing out new capabilities for the Typhoon, the Tranche 1s are too structurally and technically different from the Tranche 2 and 3 aircraft to be worth retaining for the future.

"We are continually looking at the Tranche 1 fleet, and we haven't gone down a one-way street from which there is no way back," explains Waterfall.

"Tranche 1 proved everything before it goes onto Tranche 2, but that is going to swap around in 2015 or 16, when we will stop investing in Tranche 1 and put everything on to Tranche 2 and 3.

"Tranche 1 does not feature in those plans once we get toward the end of this decade," he emphasizes.

The Tranche 1s are instead likely to act as parts donors to help sustain the life of the Tranche 2 and 3 fleets. That recycling has made aircraft like

radar will provide "full exploitation of Meteor," the MBDA-developed long-range air-to-air missile but also list an "electronic attack" capability.

In the 2020s, the Typhoon and the F-35B Lightning II will form the backbone of the RAF's front-line fighter force and the two are likely to be paired on operations. The RAF is now exploring how they could best be used together. RAF Typhoons and U.S. Air Force Raptors have already worked closely with each other during the Red Flag exercises, giving RAF commanders an idea how fourth- and fifth-generation fighters could be paired while simulation work is being carried out at the U.K.'s Air Warfare Center at RAF Waddington.

Simulation is also being used to help cut the cost of the aircraft's operation. Commanders believe greater use of synthetic training will allow it to more

# Low Profile

Franco-British UCAS agreement at Farnborough uncertain



Amy Svitak and Bill Sweetman **Paris**

**T**he international debut of the U.S. F-35 Lockheed Martin Joint Strike Fighter in the U.K. this month could obscure a formal agreement between London and Paris to begin work on its potential replacement.

In January, when France and the U.K. signaled plans to cooperate on a €200-million (\$374 million) concept study for an unmanned future combat air system (FCAS), Europe's two biggest defense spenders said a memorandum of understanding could follow at the Farnborough International Airshow in July, with a subsequent contract expected this fall.

"We hope to achieve that shortly," Philip Dunne, Britain's defense procurement chief, said during the Eurosatory exposition here June 19, emphasizing the significance of the F-35's impending arrival.

In the meantime, Dunne told reporters the two nations are "working in parallel on protocols concerning data-sharing" to enable collaborative efforts in support of the two-year FCAS study, which is expected to build on new unmanned combat air system (UCAS) demonstrators developed in Britain and Europe in recent years.

The U.K. Defense Ministry's £185 million (\$300 million) Taranis, led by BAE Systems, conducted its first flight last August. Initiated in 2006, the Defense Ministry has kept the program under a veil of secrecy, including aspects of its exterior design, which BAE says remain classified. Similar in size to a BAE Hawk jet trainer, Taranis is powered by the same single Rolls-Royce Adour turbofan fitted to

the French-led nEUROn UCAS demonstrator, though no firm decision has been made on the powerplant for the larger, Franco-British FCAS.

The six-nation nEUROn, meanwhile, completed its first flight demo in France in December 2012. Led by Dassault Aviation and the French arms procurement agency DGA, the €405-million stealthy UCAS demonstrator is midway through a two-year trial, with between 50 and 60 flight tests already complete.

"We have met all the goals set for our tests," says an industry official familiar with the program, adding that flight testing is continuing in France before moving to Italy this year for additional radar cross section tests. The nEUROn trials will then move to Sweden in 2016, culminating in a weapons drop test at the Vidsel range in northern Sweden.

In May, Dassault demonstrated nEUROn's ability to fly in formation with manned aircraft, including a Rafale fighter and a Falcon 7X business jet. The flight marked the first time that a combat UAV has flown in formation with other aircraft, offering a glimpse of how the French and U.K. air forces could employ a mix of manned aircraft, civil assets and UCAS systems in the future.

Meanwhile, if a contract for the two-year FCAS concept study is awarded this year, the project will see BAE and Dassault evaluate key technologies in preparation for a joint demonstration of a future UCAS targeted for 2020.

"This will be a study of how to mix the French and British capabilities

**French-led nEUROn UCAS is testing future fighter technologies.**

and meet force requirements," including those related to low-observability and mission systems, the industry official says.

However, both companies expect to bring more than just technical experience to their future partnership on unmanned systems, assuming the Franco-British effort continues. Beyond BAE, Dassault, and their respective top-tier suppliers, the partnership still needs to establish workshare arrangements not yet settled, though preliminary work on that topic has taken place.

Ultimately, the proposal for a four-year demonstration phase—which is expected to top €1 billion—could rely on multiple vehicles to serve as technology testbeds. In addition to a demonstrator combining some aspects of Taranis and Neuron, these could include less-costly simulators and manned platforms, such as using a Dassault Falcon to test infrared sensors.

"The biggest driver is the budget," the industry official said. "We may even reuse Taranis or nEUROn."

Securing government backing to fund the follow-on demonstration phase could prove challenging, however. With the U.K. expected to publish a new strategic defense and security review within a few months of a new government taking office next year, and French presidential elections to follow in early 2017, a decision on funding a joint UCAS demonstrator is likely to be delayed to 2018 or beyond. ☛

# New World Disorder

## Russia's actions provoke defense rethink

Bill Sweetman **Washington**

Europe marks two anniversaries this summer. One hundred years ago, an assassination in Sarajevo set off a chain reaction of ultimatums that precipitated a catastrophic and drawn-out conflict political theorists had deemed impossible and military experts considered obsolete and unnecessary. Seventy years ago, D-Day marked the beginning of the end of the last military operation by a major European nation aimed at seizing territory.

It was the last until February, that is, when Russia's re-acquisition of Crimea was accomplished quickly and with minimal force. So far, too, President Vladimir Putin's regime has maintained plausible deniability of any involvement in the secessionist uprising in eastern Ukraine. Since the westward drift of Ukraine's policy had stopped well short of NATO membership, consideration of military intervention was far from realistic in any case.

Russia has now made clear that it disfavors further encroachment by

Western Europe into its former empire. This is combined with a renewed and much better organized rearmament strategy after a series of chaotic and inefficient military adventures, ending in the 2008 war with Georgia. Military spending has been increased overall, with some strong, visible priorities.

Nuclear deterrent forces, the ultimate equalizer, have taken the lead. That includes tactical nuclear weapons—the Iskander dual-use theater ballistic missile is one of the most-produced all-new weapons in the current buildup. Airborne forces have received priority within the army: Heritage Foundation analyst Ariel Cohen observes that there are two Russian armies, one built around heavy conventional forces and the other “colonial,” as he calls it, designed for mobility and cooperation with local forces. It was the second that took Crimea, Cohen says.

Analysts also point to recent Russian writings that define a new form of warfare. In a paper for Latvia's Na-

tional Defense Academy, analyst Janis Berzins noted that in the Crimea and Ukraine Russia followed principles outlined in military journals and used minimal physical force alongside powerful and coordinated psychological activities aimed at separate targets, from discontented Russian-ethnic populations to Western European civilians.

Berzins called it “the operationalization of a new form of warfare that cannot be characterized as a military campaign in the classic sense of the term. The invisible military occupation cannot be considered an occupation by definition. Not only were the troops already on Crimean territory stationed at Russian naval bases but they were also part of the civilian militia.” The problem, Berzins argues, is that such an operation in NATO territory might not be clearly definable as an “armed military attack” in the context of NATO's Article 5, the central guarantee of mutual defense.

It is this combination of ancient national expansionism with modern technology and tactics that causes NATO countries—particularly the new members to the east—to reexamine their defense planning, as detailed in the following pages. ☛



Ukraine's armed forces, like those of other immediate Russian neighbors, remain equipped largely with Soviet-era hardware such as these Sukhoi Su-27s.

UKRAINE DEFENSE MINISTRY

# On Guard

Tensions with Russia spur new defense investments in Europe

Francis Tusa **London**,  
Christina Mackenzie **Paris** and  
Nicholas Fiorenza **Brussels**

**J**ust as many European countries thought that the tempo of military operations was changing with the drawdown in Afghanistan, so the Ukraine crisis has caused more than a little consternation.

For close to a decade, European countries have prioritized equipment and training for counterinsurgency missions at the expense of what were deemed “less relevant” missions typi-



**After 15 years when air-to-ground missions were more vital, the air-to-air capabilities of European air forces suddenly are being studied critically.**



cal in the Cold War era. The shift in emphasis, compounded by budget declines triggered by the 2008 financial crisis, has led to major capability gaps in those more traditional missions. As a result, the political panic in countries startled by the resurgent Russian military threat has been accentuated, particularly within NATO and in areas closest to Russia.

Months after tensions that began with Russia's takeover of Crimea, the attitudes of many—but not all—European players have dramatically reversed.

Take Sweden, which saw defense budget stagnation in the 2000s as it struggled to work out what its armed forces were going to be doing. The Riksdag has come toward an agreement that defense spending must rise—as much as 13% by 2022—and be heavily slanted toward procurement. The money would be spent on extra Saab JAS39 Super Gripens, cruise missiles for long-range attack, upgraded and new conventional submarines, and improvement and reactivation of heavier armored and armored infantry

brigades. All in all, the package looks very much like Sweden's defense profile in the 1970s and '80s.

Finland similarly is very likely to reverse its slowly declining defense budget, not simply because acquisition of the F-35 Joint Strike Fighter (JSF) is a priority. Just 24 years ago, Finland was still restricted to buying either Soviet or Swedish defense equipment and could not buy proper NATO equipment. Any JSF purchase would represent a remarkable jump in Finnish defense capabilities and outlook, although it would come at a steep cost.

The Baltic states, too, seem to be feeling the wind from the East more than other European players, as they move toward military modernization. Estonia is considering buying some secondhand BAE Systems Hagglunds CV90s from the Netherlands, which would be re-armed with anti-tank missiles. Estonia is also negotiating with the Netherlands for Krauss-Maffei Wegmann/Rheinmetall Pzh2000s, a move into very heavy artillery of key utility in armored-style warfare. Lithuania is buying 120 modified BAE Sys-

tems Combat Vehicle Reconnaissance (Tracked) tracked armored fighting vehicles (AFV) from the U.K. to start a process of capability enhancement for its army. It is believed to be looking at the next stage, in which it may procure tanks.

But elsewhere in Europe—the U.K., Germany, Italy and Spain—defense spending is not showing immediate change in response to developments in Russia.

Next year is an election year in the U.K., and there is no political mileage in boosting defense expenditures; German defense spending is still on a very conservative trend with little prospect of a serious rise. The defense and finance ministries in these states seem to be hoping that any perceived threats from Russia will be short-lived.

France is struggling to maintain current levels of military spending and sorting out the complications of ongoing military business deals with Russia. The most important element of Franco-Russian military cooperation to date is the €1.12 billion (\$1.52 billion) contract signed in June 2011 by Russia for two BPC Mistral-class, weaponless helicopter landing docks. French Foreign Minister Laurent Fabius suggested, albeit a bit timidly, that the contract could be aborted in light of Russia's annexation of Crimea. But he admitted in a radio interview in March that “there is the reality of employment and the economy” to keep in mind. The construction of the ships at the Saint-Nazaire shipyard has created 1,000 jobs, and the French government, whose principal economic struggle today is to contain unemployment, is reluctant to add more people to the jobless list.

A formal decision on exporting the

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vessels will be made in October by the French interministerial commission that has the final say on whether military material can be exported. Unless the situation between Russia and Ukraine degenerates again over the summer, the export license should be approved. DCNS, the French naval systems group that is the main contractor for the two BPCs, is keeping to its schedule, but insiders say the "second ship" is referred to as BPC instead of its Russian-designated name "Sebastopol."

The first ship, the "Vladivostok," should be delivered to Russia at the end of this year. Assembly of the vessel was completed a year ago and it began sea trials in March. The second ship is due to be delivered at the end of 2016.

DCNS subcontracted large segments of the construction of the BPCs to the Saint-Nazaire shipyard owners: STX France, held 66.7% by STX Europe (a 100% subsidiary of the South Korean group STX Business Group) and 33.3% by the French state.

Canceling the contract would have cost the French government €1 billion in addition to the lost jobs.

The two ships are not militarized—that would be left up to the Russians. Humanitarian missions were a key objective in the original design of the ships, which have large, extremely sophisticated hospitals. If the contract is canceled, potential buyers might be easier to find than if they were warships.

On March 21, France put the majority of its military cooperation with Russia on hold: French warships are not stopping at Russian ports, joint military exercises and staff exchanges are no longer taking place and Russian officials were not invited to attend the recent Eurosatory land and air-land defense exhibition in Paris.

However, Russian President Vladimir Putin was present at the 70th anniversary of the D-Day landings on June 6. "This is a commemoration, and we share the thousands, if not the millions, of dead who were victims of this

conflict, but also the heroes," French President Francois Hollande said.

Other measures taken by France include the deployment of four Rafale combat aircraft to the Malbork airbase in Poland for NATO air-policing exercises with the Polish air force and participation in enhanced NATO air-policing missions over the Baltic states of Lithuania, Estonia and Latvia, which do not have fighter jets of their own. The French fighters will be deployed for four months, until the end of September.

Despite the increased participation in NATO, most of the major economies of Europe are still falling short



UKRAINE DEFENSE MINISTRY

of NATO's benchmark of investing 2% of the gross domestic product in defense. In the wake of the Ukraine crisis, the Czech Republic, Poland, Latvia, Lithuania and Romania plan to increase defense spending to meet that level. Only the U.S., U.K., Greece and Estonia meet the mark now.

"Since 2008, Russia has increased its defense spending by around 50 percent, while, on average, NATO allies have decreased theirs by about 20 percent," NATO Secretary General Anders Fogh Rasmussen said last month in a speech at Chatham House in London. "This gap needs to be addressed. . . . If all European nations were to meet the two-percent spending guideline this year, we would have an extra \$90 billion to invest in defense."

NATO has approved plans to develop readiness action plans for its summit to be held in Wales in September. It also has approved the creation of new trust funds to support Ukraine's logistics, command, control and communications and cyberdefense efforts.

NATO also is working to increase the readiness of the NATO Response Force and allied intelligence and awareness, preposition equipment and supplies, and enhance exercises. The Obama administration's \$1 billion European Reassurance Initiative will help finance the pre-positioning of equipment and supplies and exercises.

At a NATO defense ministers meeting in early June, members agreed to intensify their efforts to fill key capability gaps in terms of equipment and personnel development to increase training and readiness of NATO forces across the board. They also approved a German initiative on framework nations grouping allies together to develop the forces and capabilities needed to meet NATO requirements and face new security challenges. This includes a seven-nation initiative led

### The Ukrainian military uses the Russian-built Buk-M1 launcher.

by the U.K. to develop a joint expeditionary force.

Ministers adopted a new NATO cyberdefense policy aimed at improving allied information sharing and mutual assistance, NATO cyberdefense training and exercises, and cooperation with industry.

Denmark, Germany and Poland have started work to increase the readiness of Multinational Corps Northeast in Szczecin, Poland, by reinforcing its headquarters staff so it can plan operations and exercises more quickly. The lower-readiness corps headquarters, which does not command troops in peacetime, currently requires 91-180 days to prepare for a mission.

Yet as the alliance created as a hedge against Russian aggression bolsters forces in response to the crisis in Ukraine, Rasmussen denies that NATO's missile defense efforts are tied to the recent unrest. He points out that NATO began work on a missile defense system long before the Ukraine crisis. "The aim of building a NATO missile defense system is to protect our populations against missile attacks originating from outside the Euro-Atlantic area," he says. "We will continue building our missile defense system because it's still relevant, irrespective of the ongoing events in Ukraine. And events in Ukraine will not change in any way these plans because they are not linked to the situation in Ukraine." ☛

# Eastern Promises

## How Poland is reacting to Russian aggression



RAYTHEON

Sharon Weinberger **Krakow, Poland**

**P**oland's territorial defense strategy has always been about one overriding threat: Russia. And with Russian forces massing at its border with Ukraine, the government in Warsaw is stepping up its rhetoric about new weapons and increased spending.

Having already bought 48 Lockheed Martin F-16 Block 52+ aircraft, Poland has established itself as the leading force in modernization among the new NATO countries. It has also been fighting alongside U.S. forces in Iraq and Afghanistan for a decade and is in the midst of carrying out its 10-year Technical Modernization Plan, an ambitious 130 billion zloty (\$39.3 billion) blueprint that covers everything from submarines to unmanned aerial vehicles.

The centerpiece of that modernization is the plan to buy medium- and short-range air defense systems, a program that could be worth about \$8.6 billion, the largest in Europe.

First on the agenda is the medium-range air defense system, called Wisła, which the Polish government on June 30 narrowed to two just competitors: Raytheon's Patriot system and a European-Polish consortium offering the SAMP/T Mamba. Israel's David's Sling and MBDA-Lockheed Martin's Medium Extended Air Defense System (Meads) were both under consideration up to that point.

Poland is expected to make a final decision by year-end. But in light of the crisis in Ukraine, officials in Warsaw have said they might accelerate the purchase. Analysts there are already

casting doubt on that plan, however.

"In fact, acceleration would be very difficult; the program may be accelerated, but only by a couple of weeks," says Jacek Durkalec, an analyst with the Polish Institute for International Affairs in Warsaw.

It is unclear that the companies vying for the contract can increase their production lines by any significant amount, and accelerating Wisła would be detrimental to the Polish government's plans to capitalize on the promised workshare for local industry.

For now, the front-runner in the medium-range competition appears to be the Patriot system, which has been used by the U.S. military and provides Poland with the clearest opportunity for strategic cooperation with America. Raytheon is offering Poland an open-architecture command and control system, a 360-deg. radar and the opportunity to produce a low-cost interceptor in Poland.

"The competition makes a lot of claims about cheaper operations and lower manpower," says John Baird, Raytheon's vice president for Poland's integrated air and missile defense. "It's easy to make those claims when it's never deployed and all you have are paper studies."

While Meads is not yet deployed—and still awaiting a funding decision from Germany—Lockheed fought back by offering an aggressive workshare plan for Polish industry, including co-production of the PAC-3 Cost Reduction Initiative missile in Poland. The PAC-3 Missile Segment Enhancement could contend with sophisticated

threats, while the lower-cost Polish-built missile could "thin the herd," i.e. defend against the large volume of less sophisticated threats expected during a mass raid. That apparently was not enough to sway the Polish government,

**Now just two systems are vying for Poland's medium-range air defense competition, including Raytheon with its Patriot system.**

which in its June 30 decision made clear it wanted a system already operational within NATO.

"There's quite frankly a need for long-range-capable—more than 75 kilometers—air defense missiles in that part of the world because of attrition," Coyne says.

Israel was offering David's Sling with the Stunner missile, but the U.S., which helped develop the system, was expected to block its export. Even if the Israelis had export approval, their offer in Poland was mired in allegations of corruption.

While the European SAMP/T Mamba system, equipped with the Aster-30 missile, is now a finalist for the Polish competition, it still has a major political hurdle to clear. France's refusal to cancel its Mistral-class amphibious assault ship sale to Russia has riled politicians in Poland. "[The French sale is] basically enabling Russia's power projection capability," says Tomasz Szatkowski, president of the Warsaw-based National Center for Strategic Studies.

In the meantime, Poland is pushing forward with its other procurements, and plans to boost its overall defense spending. In June, when U.S. President Barack Obama visited Poland, President Bronisław Komorowski promised to raise the funding for the Polish military to 2% of gross domestic product (GDP), from the current 1.95%, which is set by Polish law.

There remains a significant gap between rhetoric and reality, however. For example, despite the commitment to increasing its budget, the defense ministry actually returns money to the government each year. Poland should increase its defense spending to 2% of GDP, or even 2.2%, says Szatkowski, but the government must first fix its planning process. "At the moment, the ministry of defense isn't prepared to consume the money," he says. "They have to fix internal problems." ☛

# BUILD UP OR STAY THE COURSE?

**Zord Gabor Laszlo Budapest, Hungary**

**N**eighbors southwest of Ukraine are taking varying measures in response to Russia's annexation of Crimea: Romania is boosting its defense budget and Hungary is adding some new assets, while Slovakia is making no change to its planned defense spending.

Romanian Prime Minister Victor Ponta added \$200 million to the defense budget this April, after another \$100 million boost announced last fall, and Romania is now expected to spend \$2.2 billion on its armed forces this year.

Among the most important projects is an \$866 million package to acquire and upgrade nine surplus F-16MLU aircraft from Portugal as well as three two-seaters from the U.S. Deliveries are scheduled to start in 2016, while initial operating capability is expected in 2017.

In connection with the package, the U.S. Defense Security Cooperation Agency announced a potential weapons, equipment and support deal with an estimated cost of \$457 million, which includes Raytheon AIM-120C, AIM-9M and AGM-65H/K missiles, as well as Link 16 terminals.

Because Elbit Systems of America is one of the principal contractors, the use of current Romanian air force equipment with Israeli-modernized MiG-21 Lancer fighters may be part of the deal. The package may also include Northrop Grumman/Rafael Litening targeting pods, Elbit display and sight helmets (DASH) and existing stocks of Rafael Python missiles and Opher and Lizard bombs. For several years, the Romanian government has gathered information from industry to continue its ground-based air defense modernization program, which already includes Lockheed Martin AN/FPS-117R backbone and AN/TPS-79R gapfiller radars. As a next step, the country is seeking long- to medium-range surface-to-air missile (SAM) systems to replace the last S-75M3 Volhovs (SA-2) in active service with a NATO country.

Several years ago, a planned package of air defense systems for the air force fell through because of a lack of funds. The requirement to replace the obsolete 57-mm S-60 gun systems in the airfield defense role remains, however. As the two ex-U.K. Royal Navy Type 22 frigates also need an air defense solution, the SAM procurement is at the forefront of Romanian acquisition plans.

Hungary has not announced budget increases connected with the Ukrainian crisis. However, the national military strategy accepted in 2012 envisions a steady increase of 0.1% of GDP each year, beginning with fiscal 2016.

Hungary is seeking a joint acquisition of helicopters worth about \$500 million for its military, police and emergency services. Re-

cently, two deals for helicopters fell through: one to acquire surplus U.S. Marine Corps UH-1Ns and a government-to-government deal with Italy for AgustaWestland AW139s. Although a tender document for the joint deal was prepared, it has not been issued. Recent remarks by Defense Minister Csaba Hende are keeping the door open for a government-to-government contract, including joint acquisition within the Visegrad Four (V4) group of nations (Poland, the Czech Republic, Slovakia and Hungary), but Poland remains on the fence about its massive helicopter program. As a stopgap, the government in April purchased

**A Hungarian Gripen flies in an A-G configuration with Maverick missiles and a Litening targeting pod.**

three freshly overhauled Russian civilian Mil Mi-8Ts for \$14 million.

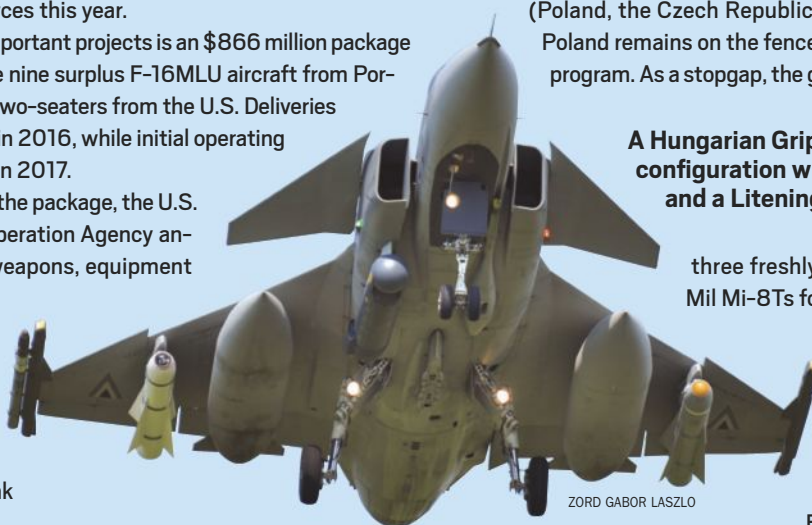
The replacement of ST-68UM (Tin Shield) mobile gapfiller radars may also happen through a multinational acquisition. At the same time, the Arzenal Electromechanical Stock Co.,

owned by the Hungarian defense ministry, is developing an all-solid-state version of the P-18 VHF radar intended to retain the frequency diversity of the air surveillance regiment's assets.

The Ukrainian crisis is thought to be a factor in the Hungarian government's decision to provide \$13 million for the close-air support capability module to the upcoming V4 European Union Battle Group, which is to become operational in 2016 and may remain a permanent structure. In practical terms, it covers air-to-ground training for Hungary's Saab JAS 39 Gripen fighter pilots and the purchase of air-to-ground weapons. Hungarian Gripens already contribute to the air-policing mission over neighboring Slovenia and will deploy in 2015 to keep watch over the Baltic states.

Slovak Prime Minister Robert Fico announced in May that his country will not increase military spending, because of the cuts in social services during the Euro crisis. However, a framework agreement to maintain its Russian-modernized MiG-29AS and UBS fighters is due to expire in 2016. Saab has proposed that Slovakia join the Czech leasing agreement for Gripens, possibly extending the numbers to 18-20 from 14. Smaller initiatives are ongoing, such as connecting the Slovak air defense brigade's modernized 9K38 Igla (SA-18) man-portable air defense system units to allied forces.

In the meantime, a NATO program called the Low Level Air Picture Interface is working on sharing radar data among allied air defense units. The results of that data sharing will be tested in a planned U.S.-Czech-Slovak exercise in September. ☉



ZORD GABOR LASZLO

# European Delivery

Romania is ready to receive  
Aegis Ashore in 2015



LOCKHEED MARTIN

**Jen DiMascio and Amy Butler Washington and Michael Fabey Moorestown, New Jersey**

**A**t a Lockheed Martin Aegis test site surrounded by New Jersey cornfields, a new ship's "deckhouse" has taken shape, containing radar system software for a ballistic missile defense system. All portable, the system will be disassembled, packed and shipped from suburban Philadelphia—then reassembled, like Legos, in Romania.

When it is fully in place in Romania and Poland by 2018, the system, with Standard Missile or SM-3 Block IIA interceptors, is expected to expand protection for European NATO countries and U.S. forces from Iranian ballistic missiles.

Missile defense in Eastern Europe has found itself tangled between the threads of domestic and international politics, with Russia scoffing at U.S. assertions that its defense systems are to protect NATO allies from North Korea and Iran, not Russia.

Russian President Vladimir Putin continues to rail against the U.S. for deploying missile defense systems to Eastern Europe on political, military and strategic grounds.

In 2009, the U.S. canceled its effort to install a long-range radar in the Czech Republic and Ground Based Interceptors in Poland, a move criticized by Republicans as a concession to Putin.

In its stead, President Barack Obama called for the installation of the "Phased Adaptive Approach" containing Aegis Ashore. The first phase saw Navy destroyers outfitted with the SM-3 Block IIA interceptor; with the second phase, a land-based system will be deployed in Romania with the same interceptor. A third phase, in Poland, will see Aegis Ashore upgraded with the more capable SM-3 Block IIA interceptor.

Tension stemming from Russia's annexation of Crimea and subsequent meddling in Ukraine has added urgency to Aegis's deployment in Europe.

When Polish Defense Minister Tomasz Siemoniak visited the U.S. in April following the annexation of Crimea, he pressed the U.S. on its plans to install the missile defense system in Poland.

"The installation is going to cover a significant part of the European territory and part of the Polish territory," said Siemoniak, through a translator. "That is why we expect that next year, the work will start, so that in 2018 the installation in Poland in [will be] ready."

The U.S. House of Representatives passed legislation to require the system in Poland to be operational by the end of 2016 and increased funding to that end. The Senate and President must still approve the measure.

The Missile Defense Agency and the Navy are working to install the Phase 2 system in Romania by the end of fiscal 2015. With a full regimen left to complete, Phase 3 is scheduled for 2018. Missile and weapons systems have not completed development, with tests on land and sea still to be conducted. Navy certification and safety trials

**The radar for the Aegis Ashore ballistic missile defense system was built to fit in the same space as a ship's deckhouse.**

are required. Construction in Poland, meanwhile, is just beginning.

During a recent tour of the Aegis Ashore facility, Lockheed officials discussed its experience with building a portable missile defense system. The company built a similar platform in New Jersey and shipped it to Hawaii for testing. Mirroring a ship's deckhouse, Lockheed kept the same type of cabling, processing and command-and-control setups.

The company sought to avoid changes requiring re-engineering or additional testing, with one major difference: Aegis Ashore will operate using a remote launcher. "Aboard the ship, the launcher is next to the radar," Brendan Scanlon, Lockheed Martin Aegis Ashore program director, says. "In Hawaii, it's three miles away. It is a big integration effort."

To make Aegis Ashore "relocatable," Scanlon says, Lockheed bolted in certain foundations and infrastructure instead of welding them, as would be done in the ship. "There is minimal welding—we have 35,000 bolts," he says, pointing to one the size of a sledgehammer.

Then Lockheed decided to connect Aegis equipment—cabling, wiring and other gear—to pallets or skids about the same size used in warehouses that could be easily packed into metal containers and shipped overseas. The pallets can be unpacked and hooked back up to identical Aegis Ashore deckhouses built by regional contractors, requiring some integration.

Lockheed has already selected the contractor team to assemble Aegis Ashore in Romania. Aegis Ashore's testing facility in Hawaii reported its first live track there Jan. 10, says Jim Sheridan, the director of Lockheed's Aegis U.S. Navy programs.

"They went live with the radar, and there was a target of opportunity," he says, "probably a commercial aircraft." ☛

# Net Effects

## Situation in Ukraine renews interest in modern air defenses

Bill Sweetman Paris

**G**round-based air defense (GBAD) was receiving more attention from defense planners in Europe before this year's increase in tension, but the Ukraine/Crimea crisis has sharpened the region's appetite. Raytheon's long-running Patriot system is one of the leaders in Poland's contest for a medium-range system, but competitors are discerning trends that might lead to different outcomes in future competitions.

Israel's Rafael company sees three trends in a "bubbling" GBAD market, an executive tells Aviation Week. The first is a tendency to combine short-range air defense with very short-range air defense, "from single-digit ranges to 30 kilometers" for the protection of mobile forces and deployed bases. The second is a customer desire to combine short- and medium-range missiles in the same system, which Rafael addresses in its Spyder GBAD system by offering common missiles based on its air-to-air weapons, in versions with or without a booster stage. The third is a combination of air-defense and counter-rocket defense.

Spyder was one of the first GBAD systems to be designed as "radar-agnostic." Unlike older systems that were designed around bespoke search and tracking radars, Spyder and emerging competitors take advantage of the capabilities of modern multirole tactical radars, with active, electronically scanned array (AESA) antennas. These radars are leading the migration into gallium nitride technology, improving range, discrimination and jamming resistance, and are capable of maintaining search coverage while tracking targets with sufficient accuracy to cue an interceptor with active radar or infrared terminal homing.

In order to exploit the potential of these radars and missiles, Rafael also offers MIC4AD (Multilevel Integrated Command, Control, Communications and Computers Air Defense), an air defense command system that can be scaled from a battalion-level unit with five consoles (four batteries and a commander's station) to a national or regional "war room." In all cases, MIC4AD takes inputs from airborne and ground-based radars and commercial and military identification systems, IDs and tags potential targets, and automatically allocates interceptors to threats.

Diehl Defense is also using adapted AAMs in its GBAD system, but rather than attaching a separate booster to its IRIS-T SLS short-range missile, it has developed the IRIS-T SL—a new missile with a maximum range of 40 km (24.8 mi.)—that retains the AAM's seeker, but has a larger

motor with a two-phase (booster and sustainer) burn profile. There is an ogival cap over the seeker dome, which reduces drag in the initial flight stage and is jettisoned before target acquisition. The sustainer burns through most of the flight profile, allowing the thrust-vectoring system to remain effective: Diehl says it is working toward making the missile maneuverable to an altitude of 20 km.

One IRIS-T SLS customer is teaming it with Australia's Ceafar radar, developed by CEA Technologies for the Anzac-class frigate upgrade program. Ceafar is a "mini-Aegis" configuration with four AESA sub-antennas. A January test firing at South Africa's Overberg range used a truck-mounted dual-antenna configuration, but Diehl and CEA are developing a four-AESA configuration where the antennas are folded onto the vehicle and swing out to cover a full 360-deg. when stopped.

The new IRIS-T SL missile is a candidate for Sweden's medium-range GBAD requirement, one of several Swedish programs that have been accelerated following the Ukraine crisis. Sweden already operates the basic IRIS-T, and would probably team the longer-range weapon with Saab's new Giraffe 4A radar.

A rather different approach to tactical GBAD is from MBDA, which received a contract in January for the 18-month assessment phase of the Future Local Area Air Defense System-Land (Flaads-L). Intended to replace the British Army's Rapier, but with a much greater range (25-km coverage versus 8 km), Flaads-L uses the same Common Anti-air Modular Missile (Camm) as the maritime Sea Cep-tor, already in full-scale development for Royal Navy frigates.

Camm differs from most of its competitors in being active-radar guided, using an all-new seeker. "The only downside to active radar is it needs a touch more power," an MBDA executive says, but—in a turnaround due to advancing electronic technology—"it is a fraction of the cost" of an imaging infrared seeker. The missile also carries a two-way datalink that can confirm the missile's location and send a signal immediately before the warhead detonates. The proposed Flaads-L launch vehicle

has two elevating masts, one for the datalink unit, the other for an electro-optical sensor that provides a clear-air, passive and autonomous engagement capability.

Another key feature of the Camm weapon is that it is cold-launched. A gas generator in the base of the launch tube drives a "pusher plug" that kicks Camm to an altitude of 25-30 meters (82-98 ft.). Another charge, in the base of the missile, fires through side vents to pitch the weapon to its initial flight attitude and orient it toward the target, all before the main motor ignites. Cold launch increases range—a missile can spend 25% of its energy getting off the ground, according to MBDA—and results in a "clean" environment with no fire or debris hazards.

The U.K. has not set an out-of-service date for Rapier, but MBDA will push Flaads-L for export earlier, to take full advantage of Royal Navy orders for the Camm. ☒



**An MBDA Camm missile is cold-launched from a demonstration-model 12-round Flaads-L vehicle.**

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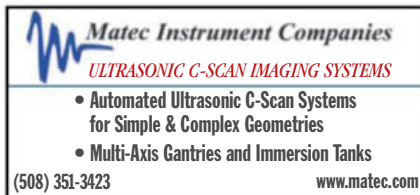
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## Future Events

- July 16**—Farnborough Civil Manufacturing Briefings, Farnborough (England) air show.
- Oct. 7-9**—MRO Europe, Madrid.
- Nov. 4-6**—MRO Asia, Singapore.
- Nov. 19-20**—A&D Programs, Litchfield Park, Arizona.
- Feb. 2-3**—MRO Middle East, Dubai.
- April 14-16**—MRO Americas, Miami.

## Aerospace Calendar

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- July 14-20**—Farnborough air show. [www.farnborough.com/airshow-20124](http://www.farnborough.com/airshow-20124)
- July 16-18**—Quantum Control User Group Annual Conference. San Diego. [www.quegroup.camp7.org/events?eventId=803805&EventViewMode=EventDetails](http://www.quegroup.camp7.org/events?eventId=803805&EventViewMode=EventDetails)
- July 19**—Washington Island (Wisconsin) Lions Club's 61st Annual Fly-In Whitefish Boil. Call Gregg Gaura at +1 (920) 847-2070.
- July 23-27**—Lawyer-Pilot Bar Association's 2014 Convention. Tamaya Resort, Santa Ana Pueblo, New Mexico. [www.LPBA.org](http://www.LPBA.org)
- July 25**—Southern African Aerospace Medical Association Biennial Conference. Netcare Conference Facility, Sandton, South Africa. [www.asma.org/news-events/events/southern-african-aerospace-medical-association-bie](http://www.asma.org/news-events/events/southern-african-aerospace-medical-association-bie)
- July 28-30**—50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference. Cleveland. [www.aiaa.org/EventsLanding.aspx?id=79](http://www.aiaa.org/EventsLanding.aspx?id=79)
- Aug. 22**—54th Annual Conference of Indian Society of Aerospace Medicine. Bangalore, India. [www.isam.in/](http://www.isam.in/)
- Aug. 25**—Ninth Asia-Pacific Congress of Aerospace Medicine. Beijing. [www.apfama.org/2014](http://www.apfama.org/2014)
- Aug. 27-28**—Fourth International Technical Specialists' Meeting on Vertical Lift Aircraft RDT&E. Patuxent River, Maryland. [vtol.org/pax](http://vtol.org/pax)
- Sept. 3-5**—ALTA Aviation Law Americas. Miami. Call +1 (786) 388-0222 or see [conferencesandmeetings@alta.aero](mailto:conferencesandmeetings@alta.aero)
- Sept. 8-12**—Fifth Pan American Aviation Safety Summit. Marriott Curacao Resort & Emerald Casino. [www.alt.aero/safety/2014/registration.php](http://www.alt.aero/safety/2014/registration.php)
- Sept. 10-12**—International Air Transport Association's 10th Maintenance Cost Conference. Divani Palace Acropolis, Athens. [www.iata.org/events/Pages/mcc-2014.aspx](http://www.iata.org/events/Pages/mcc-2014.aspx)
- Oct. 22-24**—20th Annual Cargo Aircraft Symposium. Fontainebleau Hotel, Miami Beach. [www.regonline.com/Register/Checkin.aspx?EventID=1418087](http://www.regonline.com/Register/Checkin.aspx?EventID=1418087)

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# 3-D Printing: Evolution, Not Revolution



*Alan H. Epstein is vice president of technology and environment for Pratt & Whitney.*

**A**s the English writer Samuel Johnson once said about a dog walking on its hind legs, "It is not done well, but you are surprised to find it done at all." I wonder if this isn't at the root of the recent enthusiasm in aerospace over 3-D printing. It's not that I am not suitably impressed by the ability of a relatively low-cost machine to manufacture a plastic 3-D shape from a computer description; it's just that I am puzzled by the breathless wonder of much of the media coverage. I am also skeptical of the current importance of 3-D printing to my business, making dependable engines.

This really gets to a question that is at the heart of advanced technology investment: how to distinguish between novelty and innovation? I might be more enthusiastic if this was actually new, rather than an evolution of technology in use for more than 20 years.

“ I am puzzled by the breathless wonder of much of the media coverage. ”

Aerospace companies have used 3-D printing since the early 1990s. We called it stereo lithography then. Those million-dollar-class machines created 3-D parts by employing a scanning laser beam to polymerize a liquid plastic. The resulting plastic parts were used to visualize complicated shapes during engine design, to produce molds for castings and for tooling or test parts. Sound familiar?

What's new is cost and capability. First, the price of plastic part 3-D printing machines is today much lower, now costing hundreds to thousands of dollars rather than hundreds of thousands. In addition, the evolution and spread of 3-D computer-aided design software has simplified the design process, expanding the market to more cost-sensitive, less-professional applications. Second, some machines can now produce parts from metal alloys interesting to aerospace, such as titanium and nickel.

Of course, context is important. My view is from aircraft engines rather than, for example, costume jewelry. Jet engines provide a particularly relevant aerospace vantage point to assess this technology since many engine parts fall within the size and

material capabilities of current 3-D printers. For aircraft engines, as for most aerospace parts, shape is important but material properties are equally so. In both cases, the current 3-D printing machines are lacking.

One misconception is that 3-D printers produce finished parts. The geometric accuracy of current 3-D printers is much less than required for most engine parts, the surface finish is relatively poor and final inspection is needed, all necessitating additional processing that can double the cost of the part. Mechanical properties are a mixed bag. At the moment, metal 3-D printed parts can be stronger than the same part would be if cast, but weaker than if it were forged.

Cost and time are two factors that drive aerospace development and manufacturing (quality is a third, but that is reflected in cost). Today a 3-D printed part costs less than a forged one but more than a cast part. So there is a niche where more strength is needed than a casting can provide, but less than a forging. Reflecting this value, Pratt & Whitney plans to produce several parts with 3-D printing for our new PurePower Geared Turbofan engines, which will go into service next year on the Bombardier CSeries and Airbus A320neo families. We also plan to expand our production of the powder metal needed for 3-D printing, currently used primarily for forged turbine disks.

3-D printing can yield more value to aerospace than just cost. In prototyping and product development, time is very important, so the capability to produce a highly complex shape relatively quickly can have significant value. This value is constrained, however, if the 3-D part in the test is not the one going into the production product, since the test will not certify an accurate life. Under some circumstances, it may be expedient to design prototypes or products with very small production runs using reduced performance to stay within the capabilities of 3-D printing.

What does the future hold? Will there be machines capable of producing completely finished parts of aerospace quality and strength at attractive costs? A good bet would be yes, but I expect it may take an additional 10-20 years. The visionaries who proposed 3-D printing in the 1980s called it a potential manufacturing revolution. Given that it has been more than 25 years so far with 10 to 20 years to go, I would call it evolution, not revolution. But then I am writing this sitting on a balcony in Athens overlooking the Parthenon. So perhaps it's simply a matter of proper historical perspective. ☺

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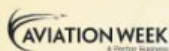
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