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July 30, 2012

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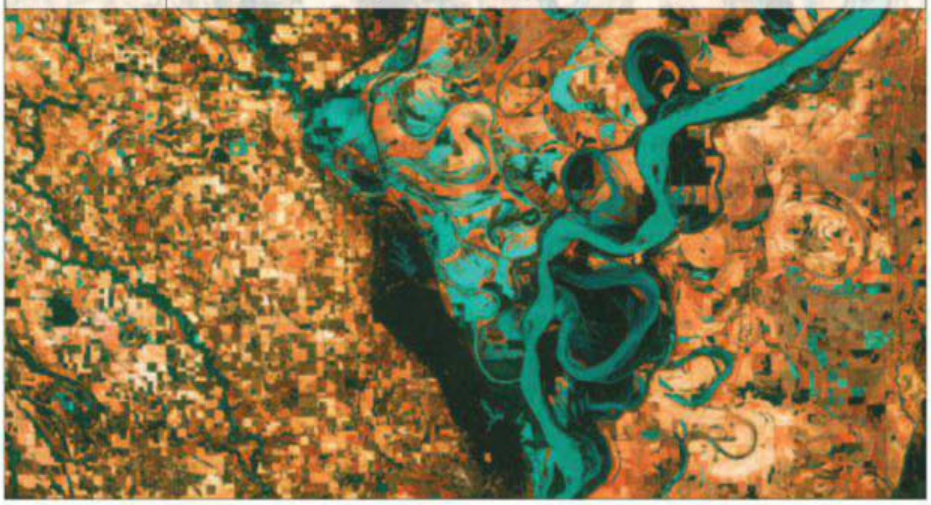

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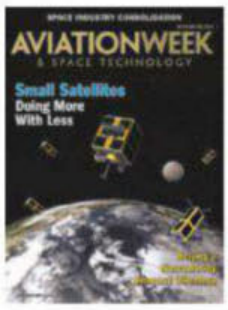

COVER STORIES

36 *Small satellites have grown more capable, sparking an expanding new industry as customers—still principally governments, and the U.S. in particular—find them increasingly attractive in a time of tight budgets, as discussed in a special report beginning on page 36. Orbcomm is paying just $6.5 million a copy for its 18 next-generation low-Earth-orbit spacecraft, and tiny cubesats can now be built from kits available on the Internet. Dynetics Inc. is at work on this upgraded version of the FastSat it built for NASA, a spacecraft that will be able to eject four cubesat relays for wider coverage of the surface below. Dynetics concept by Gary Gee.*

22 *Two major rocket engine builders hope their fortunes will improve if regultors approve Aerojet's proposed acquisition of Pratt & Whitney Rocketdyne.*

18 *The pressure on China to order narrowbody aircraft is increasing as early delivery slots become scarce for the 737 MAX and A320NEO.*

Space

ILA Berlin Air Show

ESA, BMWi, DLR, BDLI Space Pavilion – GALAXY gold awarded

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Image: ESA/NASA "ESA astronaut Hans Schlegel works on the Columbus laboratory"

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MIKE HERSCHBERG/AHS

X3 FOR U.S.A.

Eurocopter brought its X3 high-speed helicopter demonstrator to the U.S. for a tour. EADS North America is promoting the compound-helicopter's military potential and says the company is "very, very interested" in the Pentagon's Future Vertical Lift initiative (see p. 30). Watch a video of the aircraft, see photos and follow the readers' debate on the bird on our Ares blog (tinyurl.com/cty4n5n).
AviationWeek.com/ares

ORDER TRUTHS

Grupo Aeromexico's order for Boeing narrowbody and widebody aircraft is the single largest order in the history of Mexican aviation—$11 billion at list prices (see p. 20). Our Things With Wings blog takes a look behind the buy (tinyurl.com/bqz243y).
AviationWeek.com/thingswithwings

CNO On JSF

Fanning the flames of the ongoing readers' debate on the value of stealth technology for the F-35 Joint Strike Fighter program were some new comments by the U.S. chief of naval operations (tinyurl.com/cw5ewld). Catch up with the chatter and add your own comments.
AviationWeek.com/ares

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AVIATION WEEK Advantage

From the Web

Comments from readers on AviationWeek.com

FOTC

"Where the Defense Advanced Research Projects Agency (Darpa) faltered, can private enterprise succeed?" asks Senior Editor Graham Warwick. He reports on Flight Of The Century's (FOTC) flight of a modified Rutan Long-EZ with which it plans to set electric-aircraft speed and altitude records en route to its goal of developing an "infinite-range" aircraft and attempting an all-electric trans-atlantic flight to demo its technology. FOTC's ambition sounds similar to Darpa's goal for its recently terminated Vulture "infinite-endurance" unmanned aircraft program—and there are other similarities, he says. Warwick outlines them and posts artist's concepts on Ares, the Defense Technology blog.

CarpetCrawler says:

Aside from the complexity of mating/demating the two aircraft in flight, I'd think you'd need 3-4 flying batteries just to keep one UAV continuously in the air. The investment in the flying batteries and ground equipment alone appears to be significant. Why not have the UAV fly over a facility that would recharge the batteries using lasers or microwaves?

It's harder than it looks to build a small perch-and-stare UAV, even with the help of a crowd. That's the conclusion of Darpa's UAVForge competition, which failed to produce a winner for the $100,000 prize. Graham Warwick covers the contest on Ares.

Naysay notes:

Interesting, but not surprising that no winner emerged. It's a good start.

DARPA

Comment on articles, blogs and photos at: AviationWeek.com

Feedback

ACCELERATE AUTOMATION

I feel I must comment on Pierre Sparaco's column about "Henri Pitot's Legacy" (*AW&ST* July 23, p. 19).

I regret that the French aircraft accident bureau BEA's recommendations do not included implementation of the "synthetic airspeed" feature that is already in the cockpits of Boeing 787s. An enhanced stall protection algorithm was also developed for the 787.

Automation needs to be pursued further to enhance safety. The system must *assist* the pilot in all situations, including the case of an unreliable airspeed indication.

Prabowo Sumantri
MONTREAL, QUEBEC

PITOT DEBATE CONTINUES

Regarding the tragedy of Air France Flight 447: I say, blame the pitot, not the pilot.

Even we low-time pilots of Cessnas had it drummed into us to "trust your instruments; not your senses."

Training pilots in new airplanes with new computers must now, more than ever, emphasize reliance on instruments. Heck, they're not even "real" instruments but "virtual" instruments on a computer screen. At night, in turbulence, approaching a thunderstorm, and faced with suddenly having the autopilot click off due of erroneous sensor input—amid conflicting warnings and commands—which command or personal sense does one select?

My understanding of the cockpit transcripts is that the aircraft began a vertical descent of thousands of fpm. No wonder the crew had throttled back and were in a nose-high attitude when they hit the water. It would not be surprising if they no longer trusted the artificial horizon either, especially since the aircraft must have been yawing and Dutch-rolling like a leaf.

This is one of those awful conflicts between the virtual and the real world, the impact of which will continue to resonate throughout the aviation industry.

Charles Dusenbury
MONTEREY, CALIF.

CYBER CIPHER

David Fulghum's "Fragile China" (*AW&ST* June 4/11, p. 69) outlines a concern about the "threatening" cybersecurity initiatives of China and underscores the current strategic inflection of the U.S. and the world toward the Asia-Pacific region. Cyberweaponry is obviously more quickly achievable for China than its military's lagging, reverse-engineering-based developments such as aircraft carriers and indigenous "fifth-generation" fighters. One might note, however, that cyberattacks would disrupt but not disable the U.S.'s sound and ready warfighting assets and capabilities.

Rather than the "Chinese military [being] crippled by culture," Beijing's policy underlying its obviously long-range military build-up may be intrinsic to China's unique history of millennia of isolated independence. The build-up may be basically to defend "their" South China Sea against a perceived encroachment by the surrounding nations, including the U.S. China's "paranoiac" perception is comparable to that of the West's belief in China's global domination threat.

The U.S. should maintain its lead in military strength by continued investment in technology as well as capability and readiness improvements in order to prevent potential real wars. It should not engage in a cyber dogfight.

Thomas S. Momiyama
SILVER SPRING, MD.

NOT WITH A ROAR, BUT A WHISPER

I enjoyed William Garvey's hail and farewell to first-generation business jets, "Quiet Exit" (*AW&ST* July 16, p. 20). It brings back memories of when the Boeing 727 was dubbed the "Whisper Jet" by United Airlines!

I guarantee that some retired United 727 captain, now living next to famed sitcom character Morty Seinfeld in Del Boca Vista, Phase II, Fla., will send an irate email letting me know that the whisper designation referred to the inside of the cabin—not the people under the departure pattern. Of course this reputed correspondent would be correct, but the irony of the name cannot be argued.

Jonathan Gaffney, President/CEO
National Aeronautic Association
WASHINGTON, D.C.

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Who's Where

Prabu Natarajan

Ignacio Mataix

Liao Linghong

Liu Chunxi

Jack J. Pelton

Gregory Taylor

John Hinton

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

Prabu Natarajan (see photo) will become corporate VP and treasurer of the *Northrop Grumman Corp.*, effective Jan. 1. He will succeed **Mark Caylor**, who has been named corporate VP and president of the company's Enterprise Shared Services. Natarajan will continue as VP-tax, a position he held at the AES Corp. **Thomas E. Vice** will become corporate VP and president of the Aerospace Systems Sector and **Gloria A. Flach** corporate VP and president of the Electronic Systems Sector. Vice and Flach will succeed **Gary W. Ervin** and **James F. Pitts**, who plan to retire. **Linda A. Mills** was named corporate VP-operations. Other executives elevated to corporate VP and president are **Kathy J. Warden**, Information Systems; and **Christopher T. Jones**, Technical Services. **David T. Perry** was named corporate VP and chief global business development officer.

Colin Black has joined *Kratos Defense & Security Solutions* of San Diego as chief information officer. He has been chief information officer at Cymer, and VP and CIO of Mindspeed Technologies.

Ignacio Mataix (see photo), who has been CEO of the ITP Group, has been appointed president of the the *Hegan Aeronautics and Space Cluster Association*, Bilbao, Spain, succeeding **Jorge Unda**, who has been CEO of Sener, and now will be Hegan's VP. **Pedro Fuente** of Aernnova is the new secretary. New members of the board of directors are **Armando Jimenez** of Alfa Precision Casting and **Angel Alonso** of Novaltis.

Kristen Murphy has been named VP-capture management of *American Systems*, Chantilly, Va. She was director of capture management for ManTech.

Liao Linghong and **Liu Chunxi** (see photos) have become executive directors of *Ameco Beijing*. Liao will head the Operation Division and Liu the Safety and Management Division. Liao was deputy general manager of the Chengdu base of Air China Technics, and Liu was subdivision manager of aircraft overhaul at Ameco.

Damon D'Agostino has been appointed chief commercial officer of *CIT Aerospace* of New York. Based in Fort Lauderdale, Fla., he has covered global marketing and sales functions. **Gwyn Scourfield** has become senior VP and global head of marketing. He was senior regional director for marketing in Dublin. And, **Steve Mason** has joined CIT in New York as VP-aircraft analysis. He was an executive at International Aero Engines and Rolls-Royce.

Katie Pribyl has been named VP-communications for the *Aircraft Owners and Pilots Association*, Frederick, Md. She was director-communications at the General Aviation Manufacturers Association.

Nina Ward has joined the finance and acquisitions department of Denver-based law firm *Davis Graham & Stubbs* as an associate representing aircraft owners, lessors, lessees and lenders.

Derek Vanstone has been named VP-corporate strategy, industry and government affairs for Air Canada, effective Sept. 10. He is deputy chief of staff to Prime Minister Stephen Harper.

Jack Pelton (see photo) has joined the board of Denver-based *Bye Aerospace*. He was president and chairman of the Cessna Aircraft Co. until retiring in 2011.

Michael Nadal has been appointed global accounts manager of *Associated Global Systems*, New Hyde Park, N.Y. He held a managerial position in the Expedited Services Div. of ABF Freight Systems.

Gregory Taylor (see photo) has become VP-corporate strategy and business development at *Harris Corp.*, Melbourne, Fla. He was VP-sales, marketing and business development for UTC Automation and Controls Solutions.

Gabriel Maestracci has been promoted to regional director for Latin America for *Cirrus Aircraft*, Duluth, Minn., from manager of the international sales center for Venezuela and Colombia.

John Hinton (see photo) has been appointed regional sales manager of *Aircell*, Broomfield, Colo. He was principal sales manager at Rockwell Collins.

USN Rear Adm. (lower half) **Mark L. Leavitt** will become commander of the Naval Air Forces Reserve in San Diego. He has been based there as chief of staff of the Naval Air Force, U.S. Pacific Fleet. Leavitt succeeds Rear Adm. (lower half) **John C. Sadler**, who has has been appointed director of the Maritime Partnership Program for U.S. Naval Forces Europe/Africa, Naples, Italy. Rear Adm. **David A. Dunaway**, who has been nominated for promotion to vice admiral, has been named commander of Naval Air Systems Command, NAS Patuxent River, Md. He has been commander of the Operational Test and Evaluation Force, Norfolk, Va.

USAF Brig. Gen. **Jim H. Keffer**, who has been selected for promotion to major general, has been assigned as assistant deputy chief of staff for intelligence, surveillance, and reconnaissance at USAF Headquarters at the Pentagon. He has been deputy chief of the Central Security Service of the National Security Agency, Fort George G. Meade, Md.

HONORS AND ELECTIONS

Jeff Baum, president and CEO of Wisconsin Aviation, has been named vice chairman of the *Air Charter Safety Foundation*, Alexandria, Va. He succeeded **Bill Haberstock**, president of Keystone Aviation, whose term expired June 30.

By Joseph C. Anselmo

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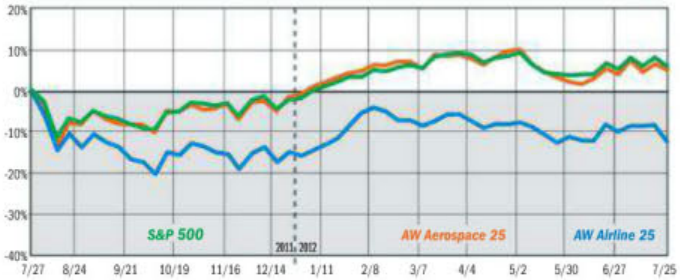
AW&ST/S&P Market Indices

(as of 7/25/2012) PERCENT CHANGE

MARKETS	INDEX VALUE	WEEK AGO	YEAR-TO-DATE	YEAR AGO
AW Aerospace 25	1412.9	-1.8% ▼	3.7% ▲	6.1% ▲
AW Airline 25	780.3	-5.6% ▼	1.6% ▲	-12.6% ▼
S&P 500	1337.9	-2.5% ▼	6.4% ▲	6.2% ▲



Weekly Market Performance

Closing Prices as of July 25, 2012

Company Name	Current Week	Previous Week	Fwd. P/E	Tot. Ret. % 3 Yr.	Tot. Ret. % 1 Yr.	
AEROSPACE & DEFENSE						
AeroVironment Inc.	23.30	24.69	16.1	-23.2	-23.6	▼
Allegheny Technologies Inc.	27.97	31.88	9.5	4.0	-55.5	▼
Alliant Techsystems Inc.	45.03	45.92	7.0	-42.3	-32.8	▼
BAE Systems plc	4.71	4.82	7.6	11.2	7.9	▲
Boeing Co.	74.03	73.89	14.8	89.1	8.2	▲
Bombardier Inc. 'B'	3.64	3.82	7.8	8.5	-35.9	▼
Cobham plc	3.55	3.73	10.7	38.3	15.5	▲
Curtiss-Wright Corp.	29.30	30.90	11.2	-9.8	-6.8	▼
DigitalGlobe Inc.	17.73	14.46	22.6	-1.4	-33.8	▼
EADS NV	33.81	33.54	14.6	120.8	15.9	▲
Eaton Corp.	42.06	39.12	9.4	79.7	-14.7	▼
Elbit Systems Ltd.	30.87	33.03	7.9	-49.0	-23.7	▼
Embraer-Empresa Brasil ADR	24.50	24.83	8.1	48.5	-14.2	▼
Esterline Technologies Corp.	57.65	59.66	9.9	99.8	-26.3	▼
Exelis, Inc	9.18	9.73	5.3	....	....	
Finmeccanica SpA.	3.23	3.60	6.1	-71.6	-62.3	▼
FLIR Systems Inc.	19.27	19.15	....	-11.2	-30.8	▼
General Dynamics Corp.	62.00	65.80	8.6	27.8	-9.1	▼
General Electric Co.	20.00	19.84	12.2	82.2	11.8	▲
GKN plc	3.12	3.33	8.1	123.1	-9.9	▼
Harris Corp.	40.34	41.35	7.9	38.0	-2.7	▼
Hexcel Corp.	23.62	25.66	14.7	133.6	-2.1	▼
Honeywell International Inc.	56.80	58.18	12.0	81.5	5.4	▲
Huntington Ingalls Industries Inc.	39.10	39.62	11.1	....	11.2	▲
L-3 Communications Hldgs. Inc.	69.62	71.03	....	6.7	-7.9	▼
Lockheed Martin Corp.	87.68	88.60	11.3	33.0	13.6	▲
Moog 'A'	35.27	38.26	10.2	27.8	-16.8	▼
Northrop Grumman Corp.	63.91	65.12	9.5	77.2	1.4	▲
Orbital Sciences Corp.	12.72	13.40	12.2	-13.2	-29.8	▼
Parker-Hannifin Corp.	76.61	76.49	10.0	68.5	-7.8	▼
Precision Castparts Corp.	160.02	167.60	...	104.8	-0.1	▼
QinetiQ Group plc	2.56	2.57	10.9	22.5	46.2	▲
Raytheon Co.	55.08	56.80	....	33.9	23.1	▲
Rockwell Collins Inc.	48.76	48.90	10.3	26.2	-12.7	▼
Rolls-Royce Group plc	12.83	13.45	14.8	119.4	27.7	▲
Safran SA	32.30	35.39	13.2	193.7	-4.7	▼
SAIC Inc.	10.85	11.45	8.2	-38.5	-32.9	▼
SIFCO Industries Inc.	19.95	22.77	....	97.5	12.3	▲
Singapore Technologies Eng.	2.59	2.61	17.8	49.7	14.8	▲
Spirit Aerosystems Holdings	22.44	21.89	9.9	46.7	6.3	▲
Textron Inc.	25.31	23.76	12.0	126.4	2.9	▲
Thales	31.49	32.91	8.3	-5.2	-5.2	▼
Triumph Group Inc.	59.09	60.24	10.6	201.9	14.3	▲
United Technologies Corp.	72.61	74.85	....	49.3	-13.6	▼

COMMENTARY

Lockheed Defies Gravity, But For How Long?

Robert J. Stevens, **Lockheed Martin's** CEO, went to Capitol Hill on July 18 to deliver a warning: If Congress does nothing to halt another $500 billion in automatic cuts to U.S. defense spending due to begin next January under a process known as "sequestration," the Pentagon's largest contractor will be forced to hand out 10,000 pink slips, riffing 8% of its workforce.

Six days later, Stevens—who is retiring as CEO at the end of the year—had a more upbeat message for investors. Lockheed Martin rolled out a second-quarter earnings report of $2.38 per share, blowing past Wall Street's consensus estimate of $1.91. Sales and profits were up from a year earlier, operating margins from business segments came in at a robust 12.3%, and the company raised its earnings forecast for 2012. Those are hardly the hallmarks of a company headed for the precipice.

Lockheed's strong results underscore how complicated investing in defense stocks has become. The consensus is that U.S. defense spending will decline in 2013 and 2014 as the government moves to rein in a massive federal budget deficit. But how far and fast the military budget will fall is anyone's guess. The risks of Pentagon program terminations were long ago baked into the valuations of stocks. The debate now is whether the prices of some of them have declined too much. Four analysts have "buy" ratings on Lockheed shares, four have "sells," and 16 rate it a "hold," according to Thomson/First Call.

RBC Capital Markets analyst Robert Stallard is one of the optimists. He believes the shares, which were trading near $88 last week, could appreciate to $98. "Lockheed retains its reputation as a quality executor in the defense sector," he says, adding that the company's dividend yield of 4.6% "will continue to appeal to risk-averse investors, even in the face of sequester uncertainties." Citi's Jason Gursky and Bernstein Research's Douglas S. Harned are even more upbeat; they have set respective target prices of $103 and $105. Both believe the outlook for the company's signature program, the F-35 Joint Strike Fighter, is brighter than headlines suggest. "The jet remains the fighter of choice for the U.S. Air Force, Navy, Marine Corps and numerous international partners," notes Gursky. "Even if the program were cut in half, it would still be worth 7.5 years of production."

Bank of America Merrill Lynch analyst Ronald J. Epstein agrees that Lockheed's "relentless focus" on returning cash to shareholders justifies a premium on its share price. But his target of $91 does not leave a lot of upside. Epstein explains that Lockheed's margins could be pinched if it does not execute on the F-35 and other programs, while lower spending by Washington will limit growth prospects. And Morgan Stanley's Heidi Wood was not swayed enough by Lockheed's results to advise her clients to buy its stock—or for that matter shares of any other major defense contractor. "We prefer to stay picky and await a more attractive entry point," she says.

Source of financial data: Standard & Poor's and Capital IQ Inc. (a Division of Standard & Poor's) U.S. dollars and cents. Forward P/E ratio uses S&P and Capital IQ forecasts of current fiscal year.

DEFENSE

New Chiefs

The U.S. Senate Armed Services Committee, which does the official work of vetting new defense officials for Congress, has approved President Barack Obama's latest nominations for the Joint Chiefs of Staff. The panel late last week approved USAF Gen. Mark Welsh, 3rd, for Ar Force chief of staff, as well as the promotion of Army Lt. Gen. Frank Grass to general and to become chief of the National Guard Bureau. Besides a chairman and vice chairman, the Joint Chiefs comprise the chiefs of the four armed services under the Defense Department, as well as the chief of the National Guard.

Unobligated Funds

Some 13% of the $6.7 billion the Pentagon is slated to spend between fiscal 2011 and fiscal 2017 for combating improvised explosive devices (IEDs) is still up for grabs, with no contractor chosen, according to an Aviation Week Intelligence Network analysis of data provided by Avascent. Countering IEDs became a major thrust for the U.S. military after operations began in Iraq and Afghanistan, and tens of billions of dollars already has been spent on counterinsurgency aircraft, Mine Resistant Ambush Protected vehicles and other equipment, such as synthetic aperture radar and Avenger-laser systems.

Jassm Test Round Complete

Lockheed Martin's AGM-158 Joint Air-to-Surface Standoff missile (Jassm) passed a milestone last week with the successful launch of an all-up round from a U.S. Air Force Boeing F-15E. The test, in which the armed missile navigated to its target and destroyed it, marked the completion of integration tests on the F-15E, the sixth platform cleared to carry the stealthy cruise missile. The test also marked the first use of USAF's Universal Armament Interface (UAI), which is intended to allow new weapons to be integrated on to UAI-equipped aircraft without changes to the aircraft or weapon software. As well as being used on F-15Es, Jassm is a candidate to arm South Korean F-15Ks.

Poseidon Audit

The Pentagon Inspector General's Office (IG) says it started an audit in June of the U.S. Navy's P-8A Poseidon maritime patrol aircraft (see photo), which is set to replace the service's P-3Cs. "Our objective is to determine whether the Navy is effectively preparing the P-8A Poseidon program for the full-rate production decision," the IG says. "Specifically, we will evaluate whether the Navy is addressing the system shortfalls and increasing its sample size to fully assess system reliability as the director of operational test

BOEING

and evaluation (DOT&E) advised before and after the low-rate initial production decision in August 2010." The most recent Pentagon DOT&E report, released earlier this year, noted several issues with the Boeing-led program.

Snail MALE

France and the U.K. have yet to sign an agreement affirming cooperation on a medium-altitude, long-endurance (MALE) unmanned aerial vehicle (UAV), but the two countries did take a step toward closer defense ties during bilateral talks in London last week. During a meeting between French defense minister Jean-Yves Le Drian and his U.K. counterpart, Philip Hammond, France agreed to conduct operational trials of the Thales-built Watchkeeper tactical UAV through mid-2013, at which point the French are likely to purchase the multi-sensor, all-weather system. A second agreement will see BAE Systems and Dassault Aviation study key technologies in preparation for a joint demonstration of an unmanned aerial combat system. The one-year agreement, valued at €12 million ($14.8 million) will be split evenly between the two allies. But a decision on joint development of the MALE system anticipated at this year's Farnborough air show will have to wait until France completes a UAV strategy review, anticipated by early fall. "We've lost a lot of time and spent a lot of money" on drone studies, said one French defense official. "We need

UTC's Acquisition of Goodrich Finalized

The U.S. Justice Department and the European Commission have given final approvals to United Technologies Corp.'s acquisition of Goodrich, clearing the way for UTC to close on the $18.4 billion mega-merger, strengthening its position as a commercial aircraft powerhouse.

UTC CEO Louis Chenevert told analysts late last week that his company expects to generate $8 billion in synergies this year from the merger, which was announced in September 2011.

Goodrich will be combined with Hartford, Conn.-based UTC's Hamilton Sundstrand unit to create UTC Propulsion & Aerospace Systems, headquartered at Goodrich's hometown of Charlotte, N.C.

Before its acquisition, Goodrich already had close business ties with UTC. Its Aerostructures unit provides the nacelle system for Pratt & Whitney's new PW1100G geared turbofan (GTF) series of engines. Former Goodrich Chairman and CEO Marshall Larsen is expected to be named to the UTC board of directors and head Aerospace Systems. Alain Bellemare, who headed Hamilton Sundstrand, has been appointed president and CEO of Propulsion & Aerospace Systems, also giving him leadership responsibility for Pratt & Whitney (P&W).

To satisfy antitrust regulators, UTC agreed to sell Goodrich's Electric Power Systems and Pumps and Engine Controls businesses and divest Goodrich's interest in Aero Engine Controls, a joint venture with Rolls-Royce. UTC also last week announced agreements to sell several other businesses to raise money to pay down debt from the Goodrich acquisition. Hamilton Sundstrand agreed to sell two of its industrial products businesses to BC Partners and The Carlyle Group for $3.46 billion, and P&W is selling its Rocketdyne space propulsion business to GenCorp for $550 million (see p. 22).

Meanwhile, P&W's second-quarter operating profit declined 1% from a year earlier as robust orders for the GTF were not enough to offset a 13% decline in airline orders for large commercial spares. Chenevert says P&W is in talks with airframers, suppliers and customers for developing a widebody variant of the GTF, which will power the Bombardier CSeries and Mitsubishi Regional Jet and is offered as an option on the Airbus A320NEO. "The GTF architecture is scalable and could go up to widebody-sized engines," says Chenevert. The new engine has attracted 2,900 firm orders and options.

an overall strategy, and that is what we are undertaking at the moment."

Indian Airlifter

India will soon release a request for proposals (RFP) for 56 cargo aircraft for its air force to replace its aging fleet of BAE Systems Avros, according to a defense ministry official. The final approval for expanding the cargo fleet of the Indian air force (IAF), estimated at $2.5 billion, was provided during a meeting of the Defense Acquisition Council headed by Defense Minister A.K. Antony last week. The RFP ". . . will make it clear to foreign players that they will have to select an Indian partner for this project," he says. Under the deal, the first 16 aircraft will be directly procured from a foreign vendor, which will then have to partner with an Indian company that will manufacture the remaining 40. Out of those 40, 16 must have 30% indigenous components, while 24 must have 60% locally procured parts. The first aircraft is expected to be delivered 4-6 years after an agreement is signed, another official says.

Canadian Contracts

Boeing has selected two more Canadian-based contractors to support Royal Canadian Air Force CH-147F Chinook helicopters. Mirabel, Quebec-based L-3 Communications MAS was among three support contractors announced in January; it has not been tapped to provide technical publications. General Dynamics Canada of Ottawa will provide a maintenance training suite and contractor maintenance training support. Boeing's support contract is valued at $2 billion over a 20-year period.

SPACE

Phoenix Contracts Let

The U.S. Defense Advanced Research Projects Agency (Darpa) has tapped ATK to modify an "existing U.S.-built, U.S. government-owned geostationary satellite bus" for the agency's Phoenix program, which is set for a 2015-16 launch. Phoenix is a technology demonstrator of the feasibility of harvesting still-usable components from non-functioning satellites in geostationary orbits. The idea is that the usable components can be attached in orbit to mini-satellites, or "satlets," saving the costs of building those components on the new spacecraft. The satlets are to be grouped in pods as piggyback payloads on commercial launches. ATK is to partner with the University of Maryland Space Systems Laboratory to develop robotic servicing tools and software to secure and reposition the working components, such as antennas, from satellites that have gone dead for other reasons. Darpa has named Space Systems/Loral to analyze the piggyback concept. Honeybee Robotics is to develop grippers and end-effectors for rendezvous and docking. Draper Laboratory is to work with Darpa to demonstrate technologies needed for the program.

AIR TRANSPORT

Full-Fare Ramifications

A U.S. court upheld new Transportation Department rules that require airlines to include all government-imposed taxes and fees in their advertised fares and let most customers cancel a reservation without penalty for 24 hr. after booking. But the ramifications of the court's decision extend beyond those new requirements, which already have been implemented. By upholding the scope of the department's authority, the U.S. Circuit Court of Appeals for the District of Columbia also cleared the way for the department to require airlines to provide all of their ancillary fee information to global distribution system providers and online travel companies. The department is considering that requirement as part of another passenger rights rule-making it plans to publish this year.

AirAsia Chooses ST Again

AirAsia and ST Aerospace have signed an $80 million, 10-year agreement for component repair management maintenance-by-the-hour support for 75 Airbus A320s. The two companies have an existing agreement covering 100 AirAsia A320s, bringing the total under the new contract to 175. The companies signed their first component management agreement in 2002 for AirAsia's five Boeing 737-300s.

Madagascar Maintenance

Air Madagascar has chosen Ameco Beijing to provide line maintenance for its Airbus A340 aircraft at the MRO's Guangzhou station in China. Air Madagascar operates two flights to Guangzhou each week and is Ameco Beijing's eighth international customer at Guangzhou.

Tear-Down Expansion

Chromalloy has found a launch customer for its General Electric CF6-50 engine teardown business in San Diego and is dismantling two Boeing 747 powerplants. This means the facility has the capability to tear down a CF6 and then manage, inspect and repair the parts. Chromalloy plans to add other engines to its portfolio later in 2012 and in 2013.

BUSINESS AVIATION

Rising Rizon

Qatar-based Rizon Jet has received new maintenance approvals from the Bermuda Civil Aviation Department for its Doha facility, allowing the company to maintain and repair Bermuda-registered aircraft at its Middle East facility as well as at its London base at Biggin Hill Airport. The private aviation company recently also expanded its line and base maintenance capabilities to include the Learjet 45 and Bombardier Challenger 300.

Gulfstream Views Milestone

Gulfstream Aerospace has delivered its 600th aircraft equipped with the company's PlaneView cockpit. The PlaneView cockpit, first delivered on a G550 in 2003, is a modular system that includes Honeywell Primus Epic avionics and Gulfstream's Cursor Control Device, which allows pilots to point and click, scroll and use push-button operations.

Corrections: *An article in the July 16 issue incorrectly identified the sponsor of the first U.S. space-station utilization conference (p. 50). The conference was sponsored by the American Astronautical Society.*

A story in the July 23 issue (p. 34) incorrectly characterized the landing minimums at Jorge Chavez International Airport in Lima, Peru. The airport's Category-2 instrument landing system allows a decision height of 100 ft., and Cat.-3 operations would allow a decision height of 50 ft.

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COMMENTARY

Out of the Lab

GE says new technologies give it an edge in engine development

There are not many secret technologies or materials in the jet engine business. All the major engine makers are working with exotic materials in the search for weight savings, emissions reductions, coatings that extend life cycles and technologies that allow faster production of complex parts.

The question is always when new technology and/or materials are ready to move from the laboratory into production.

GE GLOBAL RESEARCH CENTER

GE Aviation says it is making progress on ceramic matrix composites (CMC) on turbine shrouds for the Leap engine series that GE and Snecma are making in their CFM partnership for single-aisle jets for Airbus, Boeing and Comac. The technology also will be used in its GE9X engine that will succeed the GE90 for Boeing's 777X proposal, expected to be ready for service entry by the end of the decade. The GE/Rolls-Royce F136 engine, which was not selected for the F-35 fighter, was also an early proving ground for CMC technology.

CMCs are made of silicon carbon fibers that are one-fifth the diameter of a human hair. They are attractive because they dissipate energy, are one-third the weight of nickel super-alloys and can operate with twice the strength of the alloys at 2,400F, says GE Vice President and CMC program lead Sanjay Correa. Traditionally, ceramics have been seen as brittle. But Correa calls them a tough, hard material that is attractive as it requires little or no cooling air at high temperatures, contributing a 1.5-point reduction in fuel burn.

CMC technology is flowing out of the GE Global Research Center in Niskayuna, N.Y., where it has been studied since the 1980s. GE is approaching a million hours of CMC testing, including a 2,210-hr. test series that put 96 Stage 1 shrouds through 900 takeoff cycles.

In February, GE and Snecma formed a joint venture with Nippon Carbon Co., a specialty producer of high-temperature grade silicon carbide fiber, to produce the raw materials for the Leap and -9X programs. CMC parts can be machined like metal, and there is little excess to be trimmed, Correa says. They are protected from combustion gases with a coating of silicon.

Although CMC shrouds can be repaired, techniques for doing so are still in development. Still, in GE's view, expanding the use of CMC technology is essential for increasing engine pressure ratios, so it has an eye on rotating parts development. "CMC is really an efficiency play," says the research center's business program manager, Jack Barter. "We have the material; it's ready. It gives us additional efficiency."

The research center plays a major role in combustion research, and its No. 5 Test Cell (photo) has played a big role in scaling the GEnx TAPS (Twin Annular Premix Swirler) technology down for Leap in the TAPS II program. Next on the list are the GE9X and TAPS III. Combustion technology leader Chris Vandervort says its No. 5 Test Cell runs 6-7 days a week as GE chases emissions reductions, improved fuel-burn efficiency and longer lifecycles.

Meanwhile, GE is pushing additive manufacturing as another way to make lighter parts. The term covers about 10 different techniques for working directly from computer-generated drawings to a manufactured part by building it up one layer at a time. Its advantage is in allowing complex shapes to be formed without extensive machining and with no waste.

GE is using laser welding with a 400-watt fiber laser that is about twice as powerful as commercial machines. The technique "is most suitable for complex parts," says additive manufacturing manager Prabhjot Singh.

He says additive manufacturing parts will be used in the Leap program but declines to say where. Pressed to acknowledge whether they might be applied to the engine's hot section, he answers, "I'm not allowed to say that."

The limiting factors in additive manufacturing have always been the speed at which the parts can be built, their surface finish and costs. "We've figured out ways to design around those problems," he says. Sample parts seen recently at the research center were noticeably dimpled. Singh says tolerances of 0.001 in. have been achieved, but admits that tolerances of 0.0001 in. are needed.

While GE cites its progress as a differentiator for its new programs, Pratt & Whitney's chief technologist, Vice President Alan Epstein, doubts the technology is mature enough to provide sufficient value for customers in the current decade. To account for their brittle nature, the entire engine must be designed with the use of ceramics in mind, he says.

But Pratt recognizes their promise, he emphasizes. "We think ceramics will play a role in the future."

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COMMENTARY

Golden Turbine

Getting it right at the get-go

In all the jabbering that followed Hawker Beechcraft's remarkable announcement that it planned to sell itself to a Chinese mogul, one revelation resonated especially: If the deal does not proceed, the company will shut down jet production. And thus did the desperate manufacturer acknowledge as its essence—and key to survival—the King Air and, possibly, the A/T-6. (Sorry, but upping production of Bonanzas and Barons won't stanch the bleeding.)

PRATT & WHITNEY CANADA

And what gives those aircraft life is the PT6 (see photo), an engine that first saved its maker, Pratt & Whitney Canada (PWC), and then went on to help its parent flourish.

The PT6 is so ubiquitous it seems to simply have always been, like water. But in its pre-turbine days, the role of Big Pratt's little Longueuil, Quebec, brother was manufacturing and servicing the company's Wasp radial. That big round engine helped win World War II and launch the modern airline age. But by the mid 1950s, it was clear the turbine engine would soon reign supreme, and Longueuil's leaders knew they had to embrace it or die.

With Big Pratt in East Hartford, Conn., focused on big engines—its J57/JT3C would power everything from the B-52 and F-100, to the Boeing 707 and Douglas DC-8—PWC focused on small. But, there were two major problems. First, it had no turbojet experience, and second, there were no ready platforms.

Regardless, it pressed on, assigning a team of 12 young gas turbine engineers to bring PWC into the jet age by developing a 3,000-lb.-thrust turbojet for Canada's Tutor trainer. Though it did not win the contract, their creation evolved into the JT12, which was built in Hartford and powered the Lockheed JetStar and North American Sabreliner.

Studies of the general aviation marketplace, including discussions with Beech, Bell, Cessna and Piper, indicated that a 500-shp turboprop/turboshaft engine with high reliability held the greatest promise. So, that's what PWC set out to design.

The engine that emerged featured a free turbine since that could be mated with a simple, low-drag propeller and eliminated the need for a clutch in a helicopter. Its opposed shaft provided maintainers a easy access to the hot section. And the air intake was aft and exhaust forward, making for quieter airplanes and reducing vulnerability to foreign object damage.

After overcoming a host of technical challenges, the engine, the company's sixth propeller turbine design—PT6 for short—finally took flight in May 1961. Certification came two years later.

Beech was an early PT6 target, so PWC was taken aback when, at that year's National Business Aviation Association convention the Wichita company unveiled Model 120, a pressurized, 6-8- seat aircraft powered by Turbomeca turboprops. That aircraft never came to life, but in the meantime, Beech enticed the U.S. Army to adopt Queen Airs fitted with the small Canadian engines. The service bought a fleet of U-21 Utes and in so doing helped launch the King Air.

Since then Beechcraft has delivered about 7,000 of the type, making it the PT6's most significant customer. But it was hardly alone. The 1970s and 1980s were the Go-Go years of the turboprop when nearly every OEM turned them out as business airplanes, trainers and commuters. While many were fitted with Garrett/Honeywell TPE331s, the vast majority had PT6s under their cowls. The flood tide changed to an ebb, and the production lines of Cheyennes, Conquests and CASA C212s, ground to a halt. The Day of the Turboprop was Done, pundits posited. Longueuil laughed.

Along came a new generation of singles—TBM700, PC-9, -12, -21, Caravan, Meridian, T-6A/B, Air Tractor, AgCat, Thrush, Super Tucano, Quest Kodiak and even Israel Aerospace Industries' Heron UAV. Perhaps because everything hung on one, their makers all chose old reliable PT6. And the engine's design proved wonderfully scalable. Its three-dozen iterations range in power from 500 to more than 2,000 shp and cumulatively account for 36,000 units, and PWC adds another 1,500 annually.

Mind you, an engine type does not guarantee an airframe's success. In addition to the defunct models mentioned, let us not forget the PT6-powered Jetcruzer 500, OMAC Laser 300, and, of course, the fabulously failed Beech Starship I.

And for all its success, the PT6 has its critics. They claim its near-monopoly has made it complacent, failing to keep pace with technology—full authority digital turboprop engine control, anyone?—that its compression is too low and maintenance costs too high. GE is betting heavily that its new H80 can capitalize on those negatives.

But the PT6 has its rabid fans as well. In late April, PWC started "PT6 Nation," an on-line community in which operators post high-fives about their experiences. The site already has more than 1,500 "registered citizens." Keep in mind, the star of this fan club is a nearly half-century-old engine.

With Jet A now fetching a Dom Perignon premium, the PT6's day seems bright and long and by powering new projects like the AW609 tiltrotor, full of new promise as well.

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COMMENTARY

How High?

Ancillary revenue continues to climb

Eleven years ago, Ryanair CEO Michael O'Leary famously predicted that one day most or all of the airline's fares would drop to zero because the low-cost carrier would be raking in so much ancillary revenue from other flight and non-flight products and services.

In defense of O'Leary, who has a penchant for hyperbole, his premise was based in large part on his expectation that inflight gambling would be allowed to proliferate, which has not happened. But in that decade-plus-one, airlines have come up with many more ways to boost their so-called ancillary revenue, which begs the question: How high can that non-fare revenue go?

Jay Sorensen, president of U.S.-based IdeaWorks, suggests that the climb will stop with ancillary revenue accounting for 30-40% of total revenue at the most successful carriers. Sorensen is the author of an annual tally and analysis, sponsored by Amadeus, of ancillary revenue collected by airlines worldwide.

This year's report, released July 23, shows that total revenue collected by the 50 carriers reporting ancillary revenue as a separate category was $22.6 billion in 2011, which is up from 47 airlines reporting $13.5 billion just two years earlier. South Florida-based Spirit Airlines (see photo) collected the highest percentage of its revenue from non-fare sources in 2011, at 33%. That was about 10 percentage points higher than in 2010, in part because in August 2010 the low-cost carrier became the first airline to charge for carry-on baggage.

Las Vegas-based Allegiant Air and U.K.-based Jet2.com each attained the 27% mark. Allegiant does charge a lot of fees, but the Amadeus/IdeaWorks report notes that for both carriers a very big chunk of their ancillary revenue comes from selling vacation packages. Allegiant's parent company is Allegiant Travel, which considers itself a travel company that happens to own an airline, and it marks up prices on hotel rooms and car rental allocations that it obtains wholesale.

Airlines likely are starting to top out on how many fees they can create—and raise—for items such as checked bags, preferred seats and meals. But there still is room to raise more money by varying the prices by flight based on demand, just as carriers do in yield management of fares, and by creating fee-based perks. They also stand to gain from making more of those fee-based services available to travel agents via global distribution systems, once they get past the jockeying to try to provide that information to the GDSs on the terms most favorable to the carriers.

"There's money to be had here, and I've never seen an airline deny themselves access to more revenue," says Sorensen. "I think eventually we're going to see distribution through all channels."

There are other lucrative avenues to pursue as well. For example, Sorensen says many airlines are interested in creating "fare clubs" in which customers pay an annual fee for unique access to discounted ticket prices. That is something Spirit and Budapest-based Wizz Air already do.

Frequent-flier program partnerships with credit-card companies—which pay for the miles that customers earn with each charge on airline-branded cards—still provide a big chunk of the ancillary revenue for many carriers. But that might still have room for growth, too, even where it is well established.

The Qantas frequent-flier program generated about $146 per member in 2011—extraordinarily high even by airline standards. Qantas has managed that feat in part with its unusual step of maintaining partnerships with multiple banks, which could be difficult for some airlines to replicate, but also by making use of a point-based system that can be used at retail outlets such as grocery stores and gasoline stations.

And what about gambling? Well, that idea still shows signs of life. For example, earlier this year Ryanair partnered with the online gaming group 888.com for Internet gambling via the airline's website, with the chance to win flight vouchers.

O'Leary is not talking about getting rid of fares anymore—ancillary revenue comprises about 21% of his airline's total revenue—and no one in the industry can reasonably argue that "the sky's the limit" for ancillary revenue. But clearly there still is room to climb: Spirit just reported that its second-quarter non-fare revenue jumped to 39% of its total revenue.

GERARD ISAACSON

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COMMENTARY

Technology Flight

Testbed collects data for future exploration

NASA's open-ended technology-development program has logged its first major flight test, sending an inflatable heat shield through a suborbital parabola that subjected it to 1,000F temperatures as it plunged back into the atmosphere. The flight of the third Inflatable Reentry Vehicle Experiment (IRVE-3) could help pave the way for future exploration missions to the surface of Mars by lowering the weight needed to shield robotic and eventually human explorers from the heat of entry into the planet's thin atmosphere.

NASA/SEAN SMITH

Nearer term, IRVE could also shape commercial vehicles designed to return scientific samples and failed hardware from the International Space Station to Earth for analysis.

"Potential applications also include recovering launch vehicle assets," says Neil Cheatwood of NASA's Langley Research Center, the IRVE-3 principal investigator. "We have actually had conversations with more than one of the vendors about looking at whether this could help there."

The 680-lb. flight demonstration payload lifted off at 7:01 a.m. EDT July 23 from Wallops Flight Facility, Va., atop a three-stage Black Brant sounding rocket that carried it to an altitude of 253 nm. The payload's onboard control system flipped it over and inflated its concentric-ring structure with nitrogen into a 10-ft.-dia. aeroshell covered with a four-layer thermal blanket (see photo).

The blanket—an outer layer of ceramic-fiber Nextel, two layers of silica Pyrogel and a gas barrier to prevent burnthrough—protected the inflated structure as it reentered the atmosphere at speeds on the order of Mach 10, which generated outer temperatures of about 1,000F and mechanical loading of about 20g.

"We saw a more energetic entry than we were expecting," Cheatwood said in a post-flight press conference. "We saw about 15 watts per centimeter squared of heating. But our thermocouples actually showed a little bit lower temperatures than we would expect in response to that."

The testbed splashed down about 20 min. after launch off the North Carolina coast, where it was spotted from the air floating on the ocean surface. A U.S. Navy high-speed Stiletto boat was dispatched to locate and retrieve the experiment for analysis, but the equipment apparently sank before the Navy arrived. A NASA spokesman says no data were lost with the testbed, beyond a chance to inspect it for wear and tear. Cheatwood says telemetry data were solid, at least on an initial look.

So far there have been no formal expressions of interest in the technology for scientific space probes or recovery of samples and hardware from the ISS, although Cheatwood says NASA may offer it in future announcements of competitions for New Frontiers and Discovery missions. Meanwhile, the IRVE team will continue working on the ground to find better thermal-protection materials in an effort to raise its capability while lowering the payload weight.

At present there are no more flight tests planned in the nine-year-old project. If that changes, Cheatwood says one concept would involve using ISS garbage as ballast for a test of an inflatable heat shield returning from the station.

NASA was limited by the 22-in. diameter of the Black Brant nose cone, and also would like to increase the diameter of the inflated heat shield to gain more drag on reentry. At Mars, the more drag an aeroshell can provide on entry, the more surface is opened up to landings because an entry vehicle could be slowed more rapidly to the point where parachutes can be deployed in the thin atmosphere.

Beyond the data collected for future exploration and perhaps commercial operations, the test flight begins a process of developing enabling technologies before they are actually needed, an approach favored by President Barack Obama's NASA appointees over the mission-driven technology-pull approach used in the past.

"We're going to be doing many more tests just like this over the coming months and years," says James Reuther, deputy director of NASA's Space Technology Program.

KOUNOTORI LAUNCH

International Space Station Expedition 32 crewmembers should be unloading supplies and equipment this week from the third of Japan's H-II Transfer Vehicles (HTV-3) following its launch July 20 from the Tanegashima Space Center in southeast Japan. Carrying 4.6 tons of cargo, the Kounotori supply ship was scheduled to rendezvous with the orbiting science lab on July 27. The Japan Aerospace Exploration Agency freighter carries 3.5 metric tons of internal space station cargo, including food, clothing and scientific equipment, and 1.1 metric tons of unpressurized external cargo.

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COMMENTARY

Stumped on Security

Campaign surrogates avoid budget query

After dueling foreign policy speeches before the Veterans of Foreign Wars last week, the U.S. presidential candidates unleashed their surrogates on Washington, where a discussion at the Brookings Institution underscored both candidates' inability to answer questions on defense spending.

Speaking on behalf of the Obama campaign, Michele Flournoy, former Pentagon undersecretary for policy, outlined the military's broad budget plans, emphasizing that what is called $487 billion in cuts to defense spending over the next decade is just "a reduction in the rate of planned growth." But she dodged a question about whether the Congressional Budget Office was correct in saying the Pentagon could not actually meet its current plans at that level of spending. Likewise, Mitt Romney's surrogate, former Ambassador Richard Williamson, had to grapple with Romney's pledges to increase defense spending and not raise taxes at a time when the nation is trying to reconcile a massive deficit. The short answer is that Romney would get the money by reducing regulations that would boost the economy and thereby generate additional revenue. But Flournoy countered that Romney's proposals are similar to then-President George W. Bush's economic policy, which left the country struggling with debt and deficit. "I understand the desire to run against President Bush a second time," Williamson said, adding that Romney would rather be compared to former President Ronald Reagan.

UPI/LANDOV FILE PHOTO

'I understand the desire to run against President Bush a second time.'

AMBASSADOR RICHARD WILLIAMSON, SENIOR FOREIGN POLICY ADVISER, ROMNEY FOR PRESIDENT CAMPAIGN

FACE TIME

After years of little presidential attention during the last administration, aerospace and defense industry executives are now more in the loop with top Pentagon officials—but they don't feel any better. In the latest in a series of get-togethers, Defense Secretary Leon Panetta and several CEOs and trade organization leaders sat down last week to discuss the so-called sequestration budget cuts that are set to take effect in January. But from reports of the meeting, neither side walked away with answers or reasons to feel less anxious. According to both sides, the CEOs reiterated the devastating effect that sequestration's automatic budget cuts could have on the industrial base and the military. Panetta essentially agreed and said that is why he is trying to persuade Congress to agree to a deficit-reduction plan that would replace last August's Budget Control Act. But he also "emphasized the impossibility of planning for a sequester in a way that avoids its harmful impacts," according to the Pentagon—thus denying the CEOs details of spending reductions that they are increasingly eager to know. Both sides agreed that "sequestration will do tremendous harm to domestic and national security programs across the board." Lawmakers may be no closer to averting the budget cuts, but Congress has now passed a bill ordering the government to outline the impact of sequestration. That could force NASA Administrator Charles Bolden off the dime. Bolden has followed the administration line in saying he is not planning for sequestration, which would push NASA's $17.8 billion fiscal 2012 budget down to $16.5 billion in fiscal 2013. "Like many members of Congress and folks in the White House, Mr. Bolden stuck his proverbial head in the proverbial sand on sequestration," says Greg Keeley, vice president of intelligence and homeland policy at the technology trade association TechAmerica.

DISTILLING THE ISSUE

Politics—not policy or technology—is proving to be the biggest obstacle to developing alternative-fuel programs for the military that could prove to be successful commercial energy alternatives, says Phyllis Cuttino, director of the Pew Project on National Security, Energy and Climate. The Pentagon is employing and deploying ships and aircraft using sound technology for alternative energy, particularly biofuels, Cuttino says. The big problem appears to be resistance from lawmakers responding to constituents and special interests associated with the traditional fossil-fuel industries. "There are a lot of deeply entrenched interests," she says. Some lawmakers have argued that the Pentagon, and specifically the U.S. Navy, has no business getting into the energy business, alternative or otherwise. But Navy and Pentagon officials say federal law allows them to do just that, especially when national security is at stake.

IN QUEUE

Even as the congressional clock ticks away, a bill to prevent U.S. airlines from paying the EU for carbon emissions may yet receive attention. The Senate Commerce, Science and Transportation Committee is expected to mark up the bill aimed at blocking the EU's emissions trading system (ETS) on July 31. "If we could get a good, strong vote out of the committee, it would increase the likelihood we could get it voted on the floor," says bill co-sponsor Sen. John Thune (R-S.D.), adding that his aim is to find bipartisan support for the legislation, which faces opposition from some Democrats.

Demanding Times

Pressure rises on China as early A320NEO and 737 MAX delivery slots become scarce

Bradley Perrett Beijing

The problem with five-year plans is that they come around only once every five years. That can be a long time in commercial aviation.

As available production slots for reengined Airbus and Boeing narrowbodies move rapidly to the right, China is under pressure to set aside its usual stately planning process and hurriedly sign a round of big airliner orders.

A Chinese order for around 300 Boeing 737s is likely this year, says an executive with a major Western manufacturer that would benefit from the deal, adding that a big contract for A320-family aircraft is also expected. According to another executive, also with a big Western manufacturer, imminent deals could be preliminary contracts intended to secure slots but formally subject to later approval by the authorities in Beijing. If so, they might not immediately be counted in the manufacturers' orderbooks.

Either way, if China is to secure a useful number of A320NEO and 737 MAX deliveries before 2021, it will have to adjust its traditional Communist policy of setting out requirements for the aviation sector according to five-year plans and then ordering only when those plans are fixed. Such investment scheduling also governs other sectors of the economy.

At some point, perhaps this year, the country will also have to order hundreds of current-production 737s and A320-family aircraft, because it does not have enough narrowbodies in its order pipeline to satisfy demand while awaiting NEOs and MAXs. As far as possible, the Chinese government orders aircraft for the airline industry in bulk contracts, but a third Western manufacturing executive believes that requirements for unmodernized aircraft could be filled with a succession of orders for tens of units rather than hundreds.

Narrowbody airliners now on order for China were authorized under the 2011-15 five-year plan, industry officials say. Because it ends just after the A320NEO is due to appear and at least a year before the 737 MAX goes into service, Chinese airlines have included no new orders for those reengined types. The carriers have had to look to the next plan, for 2016-20, which should be set near the end of 2014. And, in the meantime, they have watched airlines in other countries, free from rigid central planning directives, rushing to order the updates, pushing out slot availability. Each Chinese carrier is comforted only by the knowledge that its main competitors—also Chinese—are in the same position.

The late appearance of the five-year plans has been a long-standing challenge for the manufacturers, but previously Boeing and Airbus have been able to keep slots open for the expected Chinese requirements, says an executive from a Western supplier. This time, with demand for the updated models so strong, holding enough of their slots open for another two years would be quite hard, that person says.

The A320NEO orderbook and production schedule illustrate the problem. Airbus says the NEO is sold out until 2019, with orders for more than 1,400 announced. The manufacturer should build about 500 a year in 2019 and 2020, but hundreds of those aircraft must already be allotted. Clearly, China will need to move before 2015 if it is to secure a significant number of NEOs before the 2021-25 planning period.

The same is true for the 737 MAX, the first of which is due to be delivered in the first half of 2017. Including announcements made at the Farnborough air show, Boeing holds orders for 649.

Since few if any updated narrowbodies will be available to China early in the 2016-20 period, and since the country does not have a backlog to meet its demand after 2015, it will also have to order large volumes of the current-production versions of the 737 and A320 family, industry executives point out. China's requirement for the 2016-20 period could easily reach 800 narrowbodies, they say. Chinese customers will take delivery of about 150 narrowbodies this year, but in the future they should need a faster rate of delivery. The State Council, equivalent to a national cabinet, this month issued a target for 12.2% annual growth in Chinese commercial air traffic until

AIRBUS

China is taking delivery of about 150 narrowbody airliners this year. It should exhaust its backlog in 2015 or 2016, and has no upgraded models on order.

2020, so by then the industry should be 2.5 times as big as it is now. Boeing forecasts China will buy an average of 178 narrowbodies a year over the coming two decades.

At the end of June, Chinese airlines had 470 narrowbodies on order—enough for a bit more than three years of deliveries at the current rate and approximately matching the needs of the 2011-15 plan. Some undisclosed orders for delivery by the end of 2015 could have been signed but not finally authorized by the government and therefore not announced, says a manufacturing executive, but it is likely the airlines will have exhausted their supply by around the beginning of 2016.

A complication is presented by the Comac C919, which is supposed to enter service in 2016. Comac is counting on supplying 30-40% of Chinese demand for narrowbodies and an eventual production rate of 150 aircraft a year. If it meets its schedule, some hundreds of C919s should be available for Chinese airlines in the 2016-20 planning period. And their performance is supposed to be quite comparable with that of the updated Western types.

But a difficult question is how much the airlines want to bet on the C919 appearing on time and with the promised performance and reliability. Their reluctance is evident from their having ordered fewer than 100 in contracts that, according to people who have seen the documents, have little binding effect. Clearly, the airlines cannot be eager to limit their aircraft imports because of the promised availability of the local product. Yet, just as clearly, the central government will ensure Comac's factories are busy.

A further complication must be Chinese reluctance to order from Airbus while the country remains in a dispute with the European Union over the latter's extraterritorial emissions trading system. Yet Airbus must be viewed as a realistic contender to fill a big part of Chinese requirements, otherwise pricing from Boeing might not be so keen. Besides, China has no shortage of objections to U.S. policies, such as Washington's attempts at mediating the international dispute over South China Sea territorial waters.

As to the pressure to place big orders soon, there has so far been no public reaction from the Civil Aviation Administration of China, which in shaping the purchasing policy works with the airlines, the National Development and Reform Commission (the former central planning committee) and the China Aviation Supplies Import & Export Corp., the agency that usually places the orders.

Airbus holds unfulfilled orders for about 210 A320-family aircraft due for delivery to Chinese airlines and 40 for Chinese leasing companies, a spokesman for the manufacturer says. It expects to deliver 107 aircraft to those customers, following 80 deliveries last year. So Airbus's Chinese backlog is dwindling fast.

Boeing is delivering 737s to China more slowly—26 in the first half of 2012, suggesting around 50 for the full year—and holds unfulfilled orders for 220 for Chinese airlines but none for Chinese lessors.

With Jens Flottau in Frankfurt and Michael Mecham in San Francisco.

Riding High

Boeing says its 'robust' backlog will carry it through any 2013 downturn

Michael Mecham San Francisco and Madhu Unnikrishnan Washington

The pressure for fuel-efficient jets has soaked up nearly all of Boeing's production slots for the next 12-18 months, which may frustrate customers and cause a dip in orders next year, but CEO and Chairman James McNerney says that does not mean business will be slack.

"We still see some opportunities in the mid-teens for widebodies, but by and large the pressure [will be] down after this year," says McNerney, although he notes the "robustness" of Boeing's backlog—3,924 aircraft as of June—gives it plenty of work.

As if to underscore that point, as McNerney spoke during a July 25 second-quarter earnings call, Boeing was announcing that Aeromexico plans to buy 90 737 MAXs and 10 787-9s, a commitment with a book value of $11 billion, although the contract's true value may only be half that amount.

How well the global supply chain that Airbus and Boeing share will hold up to their increasing pressure for higher production rates is subject to debate. Both manufacturers acknowledge they need to monitor their suppliers carefully.

Boeing faces production pressures in both its single-aisle and widebody lineups. Airbus has greater strength in its A320 program, less so in its widebodies. After remarkable sales last year, the A320NEO program has slowed in 2012, and Airbus chief salesman John Leahy predicts the market is passing through the peak of the current order bulge.

Boeing's 737 MAX orders have come in large blocks—Aeromexico is asking for 90—as carriers seek greater fuel efficiency with major fleet replacements. MAX has made the 737 NG obsolete, but the NG is still more fuel-efficient than many aircraft in service.

BOEING CONCEPT

McNerney is generally more bullish because of the continuing scramble of airlines to retire older, fuel-hungry models. His 737 MAX re-engining program lags the NEO, although Boeing expects it to catch up.

Boeing's book-to-build ratio of orders and production rates this year is likely to be higher than 1:1, largely because of the MAX, but "next year it may come down." He predicts the 2013 order/production ratio should be about 1:1 overall, "but it will still be a strong [order] year." Next year's order rates are unlikely to match some that Boeing has recorded since it launched MAX last year, including 150 from launch customer Southwest Airlines, 100 from Norwegian Air Shuttle, 201 from Lion Air and 75 from Air Lease Corp. But the company's expectation of 5% average annual passenger growth over the next 20 years keeps McNerney's outlook bullish.

If the company's Renton factory near Seattle could produce an unlimited supply of the MAX, airlines would discontinue ordering the now-obsolete 737 Next Generation series in favor of the reengined aircraft, he says. But MAX production will be limited as the company transitions from the NG to the MAX, which is to enter service in 2017. Boeing is both increasing production in Renton—to 42 aircraft per month in 2014—and factoring in the MAX, which has new engines and some changes to its wing, fuselage and landing gear. It is to open a third final assembly line for MAX but expects to work through a transition phase. NG orders are unlikely to fall off significantly until MAX deliveries begin.

The commercial aircraft industry continues to outpace many others, despite economic gloom in Europe and softness in airline markets elsewhere. McNerney acknowledges a "fragile" world economy. Yet airlines' drive to improve their operating efficiencies is keeping cancellation rates low, although some customers are asking for later delivery dates.

Slightly more than half of the orders Boeing is seeing are for replacement aircraft, an unusually high ratio for an industry accustomed to fleet expansions. McNerney says airlines are generally eager to replace their older equipment with more aerodynamically efficient models whose engines require less fuel. "People view them as a quick-payback investment," he says of the replacements.

In that regard, McNerney maintains that the NG series is not as disadvantaged as might be thought compared to the MAX. The older airplane still offers "dramatic improvements" in fuel burn over the 1980s and early 1990s-era jets it replaces. Against those, an NG offers a 15% fuel-burn advantage, just as the MAX does over the NG.

But there is price pressure on the NG now that the MAX is available. Chief Financial Officer Greg Smith acknowledges that Boeing has a "learning curve" underway on how to price its 737 lineup. He says some "introductory pricing" offers are being made, without being specific.

"I think we've got it well understood and we're going after it," he says of customers' push for discounts. "I'm not as concerned about it as some of the folks I've seen published so far," he adds, in a reference to Wall Street.

McNerney says the NG discounts are similar to what he's observed previously when obsolete models are replaced. "We're not going to change that," he says. "So our issue is driving productivity to offset it."

The company expects to meet its 2012 delivery target of 585-600 aircraft, although it was slightly below the halfway point at the end of June.

The 737 is now being produced at 35 per month and is to reach 38 per month early next year. The 787 is at 3.5 per month and due to hit 5 per month by year-end. The 747-8, Boeing's largest aircraft and one facing tepid demand, is holding steady at 2 per month. So far, all those rates are according to plan.

Delays in the Airbus A350-1000 development program have left Boeing's 777 in a near-monopoly position. "Early competition hasn't come true, so pricing is a little better than we assumed a year or two ago," McNerney says. Production is inching up to 8.3 per month in 2013 from 7.7. With the A350 not pressing it, Boeing's product strategy leaders feel less pressure to rush a design of the 777X upgrade models they are considering. The 777X is to enter service in 2019.

The ongoing question for Boeing and its supply chain is how well 787 production holds up. Boeing's delivery forecast calls for 70-85 787s and 747-8s to be delivered this year with numbers split about evenly. Deliveries in the first half were fairly even—11 787s and 13 747s—but below the pace needed to achieve the year-end target. The slow pace reflects customer preferences rather than production issues, McNerney says. He noted that Air India delayed accepting three 787s; the airline is working out financing with the Indian government.

The 787 deliveries will be split between aircraft undergoing so-called change incorporation work that has bedeviled the first 60 aircraft and aircraft flowing out of final assembly without need of post-production fill-ins. Production deficiencies are no longer affecting the program, although Smith says the company must keep a "close watch" on the issue because "that's where the risk is."

BOEING

Boeing delivered its first of 14 747-8 Freighters to Nippon Cargo Airlines last week. August is expected to be a busy month for deliveries of 747s and 787s, as the company catches up after a slow May-June period.

McNerney says gearbox change-outs of Rolls-Royce Trent 1000s have been completed on four of the five 787s that experienced problems at All Nippon Airways. The fifth is expected to be completed early this week; gearboxes of Trent-powered aircraft on the production line are also being swapped out. No schedule impact is anticipated.

Aft fuselage production issues in Charleston, S.C., are the 787's current "hot spot," but McNerney says, "I don't think it's a showstopper." Part shortages are down 50% from a year ago.

The Aeromexico commitment offers a window into how much airline managements are trying to take charge of fleets. CEO Andres Conesa Labastida says the purchase will move the Mexico City-based carrier from a fleet that is three-quarters leased to one two-thirds owned by the end of the decade.

The long-range 787s will replace Boeing 777-200s coming off lease by the end of the decade. General Electric won the 787 engine order for its GEnx-1B powerplants, piggybacking on GE's partnership with Snecma in the CFM partnership, which is the sole engine provider for the MAX series. Aeromexico is closing power-by-the-hour maintenance agreements for both engine types, says Conesa.

Aeromexico operates 737-700/800s and has an existing order for two 787-8s.

By maintaining a fleet that is two-thirds airline-owned and one-third leased, the airline will "have the flexibility to maintain a static fleet size of 110-120 aircraft," Conesa says. He notes that the order does not mark a large increase in capacity and is meant to replace aircraft going off lease. But Mexico's strong economic growth prompted Aeromexico to boost capacity by 7% in the second quarter.

BY THE NUMBERS

649
Boeing's firm orders for 737 MAX

46-61
Number of 787 and 747-8 deliveries needed in second half to reach Boeing's target

50%
The delivery split between 787s coming from the modification line and straight production

5
787 monthly production rate by year-end

67%
Backlog held by foreign buyers

Joining Forces

Aerojet hopes Rocketdyne deal will forge an entity greater than sum of its parts

Guy Norris London and Anthony L. Velocci, Jr. Washington

Aerojet and Rocketdyne trace their roots to the dawn of the space age, with both companies building the engines that powered multiple generations of ICBMs and manned space vehicles. But the long-term outlook for both suppliers became clouded in recent years with the sharp decline in the demand for government launch services and the advent of new, lower-cost rivals, such as Space Exploration Technologies (SpaceX).

All that will change dramatically, and they hope for the better, in coming months if regulators approve the proposed acquisition of Pratt & Whitney Rocketdyne (PWR), a unit of United Technologies Corp. (UTC), by Aerojet, a unit of GenCorp, for around $550 million. Combined, they would be only slightly smaller than Alliant Techsystems (ATK), which currently holds the lion's share of the strategic and space launch rocket-propulsion market.

The advanced booster for NASA's Space Launch System could provide an early application for combined Aerojet-Rocketdyne rocket technology.

NASA

While specific numbers remain confidential, launch systems are believed to account for $1.1 billion of ATK's $4.8 billion revenues in 2011. For Aerojet, which turned over $850 million in 2010, the income from launch systems is much smaller, representing less than 15% of overall revenues. For Rocketdyne, launch-related income in 2011 is estimated at around $640 million. Together, the two engine makers would therefore have revenues of around $800 million, so a merger is unlikely to be turned down on anti-trust grounds, say observers.

On the other hand, had a competing bid from ATK been accepted by UTC, the combined grouping would have created a relative monster with more than $1.7 billion in overall revenues. The resulting imbalance created in the market would have likely doomed the venture to failure at the hands of anti-trust regulators.

The Aerojet-Rocketdyne combination, in contrast, has only a roughly 10% overlap in terms of revenues, and preserves a level playing field for the competitive environment, say analysts. "The U.S. space propulsion sector is a critical but atrophying capability that must be preserved," says industry consultant and analyst James McAleese. "This is exactly the type of modest consolidation the Defense Department has been seeking—combinations that will increase competition and reduce overhead, which couldn't be more timely, given the growing threat of [budget] sequestration."

So what does the deal, if sanctioned, mean to the space propulsion business and to the aerospace industry in general? From a merger perspective, the combination of two liquid-rocket makers Aerojet and Rocketdyne is the latest twist in the ongoing consolidation saga that has transformed the industry during the past two decades. The pairing will create an entity with sufficient critical mass to hold its own

against the growing liquid-rocket-engine capabilities of international competitors and SpaceX on one hand, and the solid-rocket dominance of ATK on the other.

For Rocketdyne, the Aerojet deal also marks the end of a topsy-turvy ride from one owner to another, beginning in 1967 when North American Aircraft and Rocketdyne merged with Rockwell to form North American Rockwell. The company later became part of Boeing when the manufacturer acquired Rockwell International in 1996. In 2005, Rocketdyne became part of UTC when it was sold for $700 million and merged with Pratt & Whitney Space Propulsion to form PWR. UTC put Rocketdyne up for sale in March 2012 to help raise funds for the $16.5 billion purchase of Goodrich, which was approved last week.

Despite the failure of at least one serious bid earlier this year from a private equity investment group, Rocketdyne has continued to lean out and separate its operations from those of UTC in the run-up to an eventual sale. Overall employment, which peaked at 17,700 during the Apollo program in the mid-1960s, is now around 2,400—representing a reduction of around 1,000 during the past three years.

The deal also signals a major turnaround for GenCorp which, until recently, was considering the sale of Aerojet. GenCorp's chief executive, Scott Seymour, says the planned acquisition will almost double the size of the company and "create a financially healthy, stable rocket-propulsion firm with critical mass positioned to compete and produce reliable, affordable, and innovative solutions for U.S. government customers for years to come."

Aerojet, he adds, is leaner and ready for the move after years of consolidation. "Aerojet is no stranger to right-sizing, having reduced the workforce from 23,000 to 1,500 over the years."

In light of reduced budgets, fewer new programs, competition from low-cost startups and problems of an aging workforce, Seymour says, "we believe the proposed combination of our two heritage companies provides a great opportunity which helps to address many of these issues." Together Aerojet and Rocketdyne will create "a source for future innovation. This one-plus-one is going to give us a new three." Seymour adds: "Part of the integration will clearly be looking for reductions in capital infrastructure and getting the capacity right-sized between the two firms."

UTC states that "all parties are working toward a close as quickly as possible, but the sale must go through a formal regulatory approval process, which does take time. It is expected the deal will close the first half of 2013."

However, from the engine hardware perspective, the agreement continues to pose more questions than answers. For instance, both companies have been selected to conduct study work on kerosene engines for the advanced booster for NASA's planned heavy-lift Space Launch System (SLS). Working with Huntsville, Ala.-based Dynetics, Rocketdyne is proposing a modified version of the Saturn V's F-1 engine, while Aerojet is proposing a more powerful derivative of the NK-33-based AJ26, dubbed the AJ1000. The first AJ26 is, meanwhile, close to launch as the main engine for Orbital Sciences Corp.'s Antares medium-lift launch vehicle.

A combined company will therefore have two irons in the fire for the SLS booster, while the main vehicle itself is already due to be powered by Rocketdyne's RD-25D and E space shuttle main engines, and the J-2X upper stage based on the Saturn V J-2 upper-stage engine. However, Seymour declines to speculate on whether the projects would be merged, or remain separate. "We have to see what the customer is looking for. It is way [too] premature to try to determine what our offering as a combined company will turn out to be," he says.

Monopoly Money

U.S. budget pressures force commercial imaging consolidation

Amy Svitak Paris

DigitalGlobe's proposed $453 million takeover of competitor GeoEye ends a year of speculation as to whether the two commercial satellite imaging providers could survive the current U.S. budget crunch.

Both companies have made substantial capital investments based on what they believed was the government's commitment to EnhancedView, a decade-long program valued at $7.3 billion under which the Pentagon is buying high-resolution optical satellite imagery from DigitalGlobe and GeoEye. But two years in, the government has failed to live up to its end of the bargain, signaling earlier this year that it would cut funding for commercial satellite imaging purchases planned by the industry's largest customer, the National Geospatial-Intelligence Agency (NGA).

The resulting merger proposal announced last week would create a single entity to be run by Longmont, Colo.-based DigitalGlobe, one that both companies say will be less reliant on the government to survive. DigitalGlobe CEO Jeffrey Tarr says he sees no regulatory barriers to the merger, which he expects to close in late 2012 or early 2013. But the acquisition raises questions about the future industrial base, which would have fewer satellites to build and launch, not to mention the competitive global landscape.

The Obama administration's failure to make good on promised investments that led to the creation of two publicly traded companies also could undermine the credibility of the U.S. government as a partner. More broadly, as the White House embarks on a review of the nearly decade-old U.S. Commercial Remote-Sensing Policy, the merger has implications for the nation's strategy in space.

"This is obviously a positive business development for two public companies facing considerable uncertainty," says Kevin O'Connell, CEO of Innovative Analytics. "But we still need to make sure we're pursuing a commercial strategy, and the government really has to understand what that means."

In the months prior to the merger, as rumors of pending EnhancedView cuts circulated, the combined value of the two companies' stock dropped by almost 50%, or about $1 billion.

Several weeks before DigitalGlobe announced plans to acquire GeoEye, the Herndon, Va.-based company attempted its own takeover, a move DigitalGlobe promptly rejected pending further clarity on U.S. government budget cuts. In June, NGA told DigitalGlobe it would receive the full complement of funding for the third year of the 10-year EnhancedView program. But GeoEye was informed that its funding was in doubt.

With GeoEye identified as the loser in the budget arbitrage, its stock tanked further, presenting an opportunity for DigitalGlobe to offer $20.17 per share, a 34% increase over where the stock had been trading prior to the decision. For GeoEye shareholders unhappy with the new terms, DigitalGlobe is offering shares in the new company or a combination of cash and stock.

Going forward, the combined operation would result in $1.5 billion in savings over 10 years, much of it coming from reduced capital investments in building and launching satellites the companies would field if they continued to operate independently. Combined, DigitalGlobe and GeoEye operate a fleet of five Earth-observation satellites. In addition, each company has one satellite under construction, slated for launch in 2013 and 2014. However, the proposed new entity envisions a constellation of just three satellites, and plans to reserve one of the two currently under construction as a ground spare unless the U.S. government determines it needs more imagery.

Some government officials speculate that the need for commercial imagery in the coming years might be less than initially forecast, given the Pentagon's own fleet of extremely high-resolution optical satellites.

Obama's 2013 funding cuts are said to be based on classified studies of commercial imaging requirements conducted by the Office of the Director of National Intelligence and the Office of the Under Secretary of Defense for Intelligence. To date, however, these White House-mandated studies remain classified, and the administration has yet to make clear its intentions on EnhancedView, or whether the fiscal 2013 proposal to effectively zero GeoEye's funding is a permanent policy change or a temporary adjustment.

In the meantime, it is unclear whether the U.S. Congress will accept the current scenario. Earlier this year, at least one committee sought to maintain the status quo under EnhancedView until an assessment of U.S. national security requirements and industrial base concerns can be carried out.

Predicting that proposed funding cuts would lead to the demise of at least one of the companies, the U.S. Senate Armed Services Committee said in a report accompanying its fiscal 2013 markup of Obama's budget request that the government's "wild swing in demand" exposed DigitalGlobe and GeoEye to financial risk and could lead to a monopoly in the market.

However, when GeoEye made its offer to purchase DigitalGlobe in May, it urged the government not to view the merger as creating a monopoly. The market, GeoEye said, is global.

Speaking to investors during conference call last week, DigitalGlobe's Tarr echoed that sentiment when he said the new entity would rely on the U.S. government for only 50% of its earnings and that the merger would leave DigitalGlobe well-positioned to compete internationally.

As the company's largest competitor outside the U.S., Paris-based Astrium Services did not miss an opportunity to point out the contrast between the French-government backing for optical satellite imagery and the U.S. government's $7.3 billion commitment to EnhancedView.

France has financed most of the development costs of Astrium's medium-resolution Spot satellite system since its inception in the mid-1980s. But that ended after Spot-5 was launched in 2002. By the time DigitalGlobe and GeoEye signed their EnhancedView agreements in 2010, Astrium had no commitment from the French government for Spot-6 and -7, and had yet to loft its first high-resolution optical imaging satellite as part of the Pleiades constellation.

Today, with Pleiades 1a in orbit—and plans to loft Spot-6, Pleiades 1b and Spot-7 within the coming year—Astrium is in a good position to take on DigitalGlobe in the commercial remote-sensing market. However, if a more muscular entity emerges from the proposed acquisition, the new company would boast key advantages against foreign competitors, including the recent expansion of GeoEye's data analysis center in Tampa, Fla. The office is one component of a virtual analytics center that will aggregate and analyze unclassified imagery and open-source data to predict areas where national security threats are likely to emerge.

"As more and more satellites populate the sky, the real action will be on the ground," says O'Connell says. "We're heading into a world where the analysis of geospatial data and the fusion of geospatial data will be far more important than any single collector."

France's high-resolution Pleiades constellation reserves capacity for the French military while permitting Astrium GEO-Information Services to sell imagery on the commercial market, where it hopes to compete with U.S. providers DigitalGlobe and GeoEye.

CNES/PIERRE CARRIL CONCEPT

Limiting Factor

NASA is pushing to overcome 'frontier' demands on ISS crew

Frank Morring, Jr. Washington

NASA is pressing to use everything from robots to Russians in an effort to stretch the crew time available on the U.S. side of the International Space Station for research.

William Gerstenmaier, associate administrator for human exploration and operations, says he is "narrowing down" the list of candidates he will select as early as this week for the agency's Commercial Crew Integrated Capability effort, which will provide substantial seed money for at least three private efforts to deliver crews to the ISS as early as 2015.

A commercial capability would allow the space station's crew to grow from six to seven by providing a four-seat vehicle for emergency departures in addition to the three-seat Russian Soyuz capsules in use today. But until that capability is ready, a backlog is building for the three station crewmembers assigned to work in the NASA-controlled modules of the ISS.

Don Pettit, who returned from his second stint on the ISS July 1 after 193 days in orbit, says U.S.-side crewmembers are averaging about 6.5 hr. per day of research time, when it is available. Overall the U.S.-side crew is posting 35 hr. per week of research as counted by NASA's ISS program office at Johnson Space Center (*AW&ST* June 25, p. 25). "Currently crewmembers are working 13 or 14 hours a day, and out of that we can get about 6.5 hr. of mission programmatic work done," Pettit told the Senate Committee on Commerce, Science and Transportation July 25. "That's because we're in a harsh frontier, and we spend 13 or 14 hours a day just to keep the machinery going and keep it possible for human beings to be there. You'll find this is commensurate with other frontiers that are harsh on the surface of Earth."

NASA/JOHNSON SPACE CENTER

Astronaut Don Pettit says working on the ISS is like conducting research from tents in Antarctica.

Pettit says the time necessary to survive on the ISS is comparable to his experience living in a tent 200 mi. from the South Pole while on a meteorite-search expedition in the southern summer of 2006-07. Because of the need to spend crew time maintaining the ISS, he and Thomas Reiter, another former station crewmember who is director of human spaceflight and operations for the European Space Agency, say there are limits to how much more time can be squeezed out of the packed crew days.

"The next years will show where there are areas for improvement," says Reiter, suggesting greater use of large multi-user facilities already on the station instead of customized experiments may help.

Ultimately the best way to get more research is to increase the crew. At a June station-partnership meeting in Moscow, representatives from NASA and Russia started discussions on bartering for Russian crew time to conduct research on U.S. facilities (*AW&ST* July 16, p. 50). Gerstenmaier says those discussions are continuing as a way to boost crew time until the commercial crew vehicles start arriving. Now that it has been certified for use in space, the Canadian-built Special Purpose Dexterous Manipulator—a large robot known as Dextre that rides on the station's robotic arm—can also help, he says. Every time ground controllers teleoperate Dextre to swap a worn-out spare part with a special Orbital Replacement Unit designed for robotic handling, it saves the crew a time-consuming spacewalk, he notes.

There already is a backlog of experiments on the ISS awaiting crew time, Pettit says, and that backlog is likely to increase. James Royston, the interim director of the Center for the Advancement of Science in Space (Casis), says his organization has received 30 unsolicited proposals for research in the U.S. National Laboratory, and has visited more than 160 private companies and other organizations soliciting new research.

NASA hired Casis to run the National Lab, which Congress established on the ISS as a way for nontraditional companies to use the facility. But its startup was hampered by the difficulty of setting up a new organization, and by bureaucratic infighting that led to the resignation of the group's first executive director (*AW&ST* June 25, p. 45). Royston says Space Florida, the state development organization that set up Casis to bid for the National Lab contract, will announce a new executive director and permanent board of directors "soon." That should smooth the way ahead for getting new research in line to go to the station.

The commerce panel's hearing was chaired by Sen. Bill Nelson (D-Fla.), who said he called it to generate interest in the orbiting laboratory and the Florida-based organization that runs the National Lab. He said it is likely that Congress will extend funding for station operations beyond the current 2020 shutoff. Engineers have determined that the structure Nelson terms an "extraordinary contraption" should hold together until 2028. After that it could be split up and parts of it reused as human habitats in cislunar space, an approach already under consideration inside NASA (*AW&ST* Oct. 10, 2011, p. 46). "Maybe as a future base parts of it could be used in that situation as a way station if we decide in our future exploration that we want to go to the Moon's surface again," Nelson says. "These are the possibilities."

Sally Ride: 1951-2012

First U.S. woman in space continued to advance human spaceflight long after her historic mission

Frank Morring, Jr. Washington and Michael Mecham San Francisco

For Sally Ride, who died July 29 of pancreatic cancer, being the first U.S. woman in space was only the beginning of a long and productive career applying her experience to spaceflight safety, education and U.S. space policy.

On her historic first mission—STS-7 in June 1983—Ride pioneered use of the Canadian-built shuttle robotic arm to deploy and retrieve free-flying satellites. On her second—like the first aboard the space shuttle Challenger—she helped test satellite refueling techniques.

Ride's third mission was canceled after Challenger exploded during its ascent on Jan. 28, 1986, an event that ended her spaceflight career and opened a new role as a top-level adviser to the nation's spaceflight leaders. She was the only person to serve on the two presidential panels set up to investigate the Challenger and Columbia accidents.

WHITE HOUSE

Sally Ride helped shape President Barack Obama's space policy as a member of the Augustine panel.

As a young astronaut—she was 35 at the time—Ride expressed surprise as testimony before the Challenger accident-review panel revealed the amount of danger inherent in a shuttle ascent. Later, she strongly backed ending the payload-specialist program that flew outside scientists and other researchers because of the risk, and argued that shuttle flights should be reserved for highly trained astronauts.

The Columbia Accident Investigation Board reprised many of the findings of the earlier panal, including strong cautions against complacency and the dangers of schedule pressure in launching orbiters. The shuttle program took the warnings to heart, and was able to use the winged spaceplane to complete the International Space Station before retiring it without incident.

Ride was a nationally ranked tennis player who held a doctorate in physics from Stanford University and a bachelor's degree in English. She joined NASA in 1978 as a member of the first astronaut class to include women, and served as a ground communicator to the crew on early shuttle missions before being tapped for the STS-7 flight. In addition to her spaceflight experience, she was the agency's first director of exploration and first director of strategic planning.

In 1989, Ride left NASA and joined the University of California-San Diego as a professor of physics. She was a fellow of the American Physical Society and a member of the boards of the California Institute of Technology and The Aerospace Corp. In 2009, NASA named her to the outside Review of U.S. Space Flight Plans Committee, commonly known as the Augustine committee after former Lockheed Martin CEO Norman Augustine, its chairman.

The panel determined that the Constellation program established by President George W. Bush to develop vehicles for "Moon, Mars and beyond" exploration was underfunded, and suggested options for a new direction. Ride sat on the subcommittee that studied access to low Earth orbit, which deemed the commercial approach ultimately adopted by President Barack Obama as "within reach."

In addition to her academic and advisory work, Ride devoted herself to inspiring schoolchildren to study science and math. She founded Sally Ride Science in 2001 to advance that work through programs that used spaceflight as an enticement. The twin Gravity Recovery and Interior Laboratory (Grail) spacecraft orbiting the Moon includes a "MoonKam" feature promoted by Ride. MoonKam allows middle-school students to program inexpensive fixed cameras on the Grail orbiters to gather specified images of the surface below (*AW&ST* Jan. 9, p. 16).

Ride was intensely private, keeping her personal life to herself, including the lesbian sexual orientation that she revealed publicly only in the obituary that she wrote with her life partner of 27 years, Tam O'Shaughnessy. That posthumous disclosure sparked a lively debate last week over whether she should have "outed" herself earlier as a gay role model. Astronaut Steve Hawley, who was married to Ride from 1982-87, declared that her work with students was "role model enough."

"While she never enjoyed being a celebrity, she recognized that it gave her the opportunity to encourage children, particularly young girls, to reach their full potential," Hawley wrote in a statement released by NASA. "Sally Ride, the astronaut and the person, allowed many young girls across the world to believe they could achieve anything if they studied and worked hard. I think she would be pleased with that legacy."

Heavy Duty

Military evaluation dominates upcoming testing for A400M Atlas

Guy Norris Los Angeles and Leithen Francis Singapore

The A400M airlifter has been through more than its fair share of development and cost issues on the road to service entry, but with its operational debut on the horizon, Airbus Military is gearing up for a hectic final phase of military-specific testing.

At the same time, the aircraft maker is reassuring initial customers that first deliveries remain on track for 2013 despite additional issues with the A400M's turboprop engines, the latest of which prompted a precautionary withdrawal from the flying display at the recent Farnborough air show.

Three of the airlifters, now officially named the Atlas, will be delivered to France next year and one to Turkey, according to head of market development, Didier Vernet. In 2014 the company aims to deliver 10 aircraft, including first deliveries to the U.K. and Germany. Overall since first flight in December 2009, the A400M's civil certification program had achieved around 1,150 flights and 3,500 flying test hours. The company's near-term goal is to reach 3,700 flying hours to achieve civil certification, but once that milestone is achieved, it will log an additional 700 flight-test hours, Vernet says. Civil certification will come by year-end, he adds.

Major flight-test milestones remaining include air-to-air refueling. The aircraft is primarily a troop and cargo transporter, but pods can be attached under the wings to turn the A400M into an aerial refueler. "We've been doing work with the receiver but [have] not done it with fuel yet," Vernet says. He says tests must be carried out to see that the A400M can refuel helicopters and fighters. Malaysia's air force, which has ordered four A400Ms, has committed to buying the pods and kits so it can use its A400Ms as aerial tankers.

Four sessions of air-to-air refueling testing, in which contact was made but no fuel passed, have been conducted with VC10, C-160 and A330 tankers, says A400M chief test pilot Ed Strongman. "This year is all about military testing, whereas last year was getting civil certification. Now we're getting into the real meat of military flight testing," says Strongman. Handling behind the VC10 was "the hardest" because of that aircraft's high set T-tail and the resulting wake, he adds. The work with the VC10 included low-speed handling and contacts with various flap settings. Tests with the C-160 were conducted in June.

"The next stage is where we bring in the customers to get their input and for certification," says Strongman. These groups cover various disciplines of the test and certification process and, in the case of the 'flight' panel for instance, include air force representatives from Belgium, France, Germany, U.K. and Spain. "We next need to fuel with an MRTT [A330 multi-role tanker transport] and slot that into our test program" he adds. The "wet" contact work will be flown by MSN4, which has a suitably configured fuel system installed. Earlier generic testing was undertaken by MSN1 and 2.

Recent ground tests included loading trials in Germany with an NHIndustries NH90 helicopter, and in France with a French air force Eurocopter EC725 Super Puma. The latter trials, which were conducted in Toulouse, saw the Puma loaded and secured in 6 min. The more complex loading procedure for the NH90, which took 14 min., also involved the first time the internal cargo bay winch on the A400M had been used "in anger" for real military payloads, says Airbus Military test load master Pete Jones.

Airbus is also gearing up to conduct static-line paratroop jump tests in Spain and France. The evaluation follows the first set of tests to determine the correct length of the static lines from the cargo ramp and the side paratroop doors. These also helped determine that the optimum deflection angle for the side-mounted baffles that protect jumpers and ramp dispatchers from the slipstream. "We found 30 degrees was the best angle," says Jones.

Airbus Military still has to conduct air drops of cargo and paratroopers, as well as additional hard and soft landings and more cold and hot-weather tests, Vernet says. Flight tests of the aircraft's air defense systems, such as chaff and flares, also are scheduled.

"There's still some tidying up to do with the flight-control computer laws, which we will do in tests with an A330 and then we move into wet contacts," Strongman adds. Overall there have been six iterations of the flight-control laws which have been progressively refined as the flight tests progress. The A400M system is based on those developed for the Airbus commercial line, and most closely resembles that of the A380. However, unlike its commercial brethren, the fly-by-wire A400M is configured with several adaptations to reflect its military role. "We have a law which changes gain for tanking. To modify the system we acti-

Military-role flight-testing is ramping up as the A400M nears completion of civil certification.

AIRBUS MILITARY/S. RAMADIER

vate air-to-air refueling mode," he adds.

Five A400Ms are flying in the certification program. Vernet says aircraft MSN4 will be kept for future tests, until at least 2018.

A400M engine maker Europrop International (EPI) meanwhile remains confident that the last-minute issue with the TP400 engines that kept the airlifter on the ground at Farnborough will be solved promptly. A few days prior to the show event, a diagnostic system detected metallic chips in one of the engines on MSN6—the first production-standard aircraft to appear at the show.

The debris indicated deterioration on one of the unit's roller bearings says Europrop President Simon Henley. The engine maker believes the occurrence of deterioration on a TP400 with such few hours indicates a "one-off" flaw with the bearing rather than a more serious systemic issue.

However, the impact of the bearing analysis as well as investigations into an earlier incident in which an engine was shut down inflight following the onset of vibration "are impacting on functionality and reliability" (F&R) testing, confirms Henley. The interruption, which took place roughly halfway through the 300-flight-hour F&R phase, will delay delivery of the first production aircraft by a month, he adds. However, "it will not impact entry-into-service with the French air force," he affirms.

The vibration, which caused an engine to be removed during F&R testing in Oman, was "a completely unrelated issue" to a previous, similar vibration-related event. "But this was a different

Opening Up A Little

Local military base displays a combat helo to the press and even answers some questions

Bradley Perrett Beijing

BRADLEY PERRETT/AW&ST PHOTOS

No startling details of military strategy were revealed, nor were wraps taken off a secret weapon. But the Chinese defense ministry at least took a small step toward greater transparency last week by opening an army aviation base to journalists, including foreigners, for the first time.

The habitually secretive military allowed close inspection and photography of Z-9WZ armed reconnaissance helicopters carrying a variety of weapons. It also laid out the range of armament available for the type. Even the cockpits of Z-9WZs were revealed, along with helmets fitted with what looked like low-light goggles.

However, the new Z-10 attack helicopter did not appear at the open day, held at the base of the 4th Helicopter Regiment at Tongzhou, near Beijing.

Foreign countries, including the U.S., urge China to be more open about its defense capabilities. Although officers here say they are trying to increase transparency, activities such as allowing journalists to poke their heads into combat helicopters do not come at all naturally to the People's Liberation Army.

The other step forward at Tongzhou was that Chinese officers were willing to answer outsiders' questions, at least to a limited extent, notes Richard Fisher, an analyst with the International Assessment and Strategy Center.

The 4th Helicopter Regiment has 12 Z-9WZs among a total of 30 aircraft, one officer says. The others are Mil Mi-17 and Mi-171 transport helicopters imported from Russia and Y-7 and Y-8 transport airplanes—locally built Antonov An-24s and An-12s, respectively. Among 1,000 people in the regiment, half are qualified as pilots.

Journalists had not previously been allowed on the base, officers say.

"Our simulator training has advanced greatly," regiment commander Col. Zhang Zhilin tells Aviation Week. "We previously used actual [flight] training but now we train mainly with simulators. Doing so cuts costs, and the scenarios are realistic."

Asked to name an aspect of the regiment's performance with which he is dissatisfied, he says there is none. "Of course that sounds like self-praise, but it is true." And he adds: "We're very good at flying in bad weather."

As to the arrival of the Z-10 at the regiment, Zhang dodges the question,

The Chinese military has allowed close inspection of the interior (left) and weapons (below) of the Z-9WZ.

cause. We have done comprehensive testing to the point where I can say with confidence that the modification we've done for another reason will take this issue away," Henley adds.

The recent vibration problem involved a development engine, and not a production engine. A special test is planned to confirm this.

To verify the source of vibration, gearbox system developer Avio modified a test rig in Turin, Italy. The rig, originally developed to investigate the initial resonance problems in 2011, was brought back for this event says Henley. "We altered the rig to put in new gears, and we know we've got the cause."

EPI has meanwhile delivered five production-standard TP400s so far this year out of a planned run of 14 for 2012. This will rise to 30 in 2013. The recent issues "shouldn't detract from the fact that we've had very few problems. The pilots are delighted with the responsiveness, and we've delivered the last but one software releases," says Henley, who adds that the final load is "on track" for delivery by year-end.

EPI is also working through the final elements of the in-service support contract with the French air force, which is set to take the first A400M in March 2013. Along with Airbus, EPI says it is now starting the same talks with the next nations in line, Turkey, U.K. and Germany. The Royal Air Force says the first of its 22 A400Ms will be delivered in 2014 with initial operational capability with three aircraft due in 2015. Full operational capability (FOC) is expected by 2018 when 12 aircraft should be available.

only saying that new equipment is a matter for his superiors.

The regiment's missions have included recovery of Shenzhou manned space capsules, and it participated in rescue operations after an enormous earthquake struck Sichuan in 2008.

The Z-9WZ is "the first kind of armed reconnaissance helicopter" to equip the Chinese army, the regiment says, although this seems to overlook earlier armed versions of the Z-9 series.

The Z-9WZ appears to be the latest standard of armed helicopter in the Z-9 series.

Reflecting the attack role and the weight of sensors and weapons, the passenger cabins of the helicopters displayed at Tongzhou were largely bare, with only two seats, facing forward, and a hefty rack of electronic black boxes.

Weapons on display at Tongzhou included PL-90 air-to-air missiles, Type 23-2 cannon of 23-mm caliber, one kind of air-to-ground rocket of 70-mm caliber and another designated Type 57-1 of 57-mm caliber. Launcher pods of the rockets were also shown. But more-advanced weapons, including the HJ-10 anti-tank guided missile, were absent.

Along with mechanical gauges, the Z-9WZ's cockpit featured a small central flat display, possibly for a moving map, and two large displays, one in front of each crewmember. The buttons on the displays lacked labels, indicating multiple functionality, but there was no indication of the degree of integration of the sensors and weapons.

The Z-9, based on the Eurocopter Dauphin, has been built since 1981 at the Harbin plant that is now part of Avicopter. The correct designations for various armed versions of the Z-9 series have not been clear, so one helpful point of the Tongzhou open day was confirmation of the name Z-9WZ for the configuration of the aircraft on display. It seems to represent the most recent development of the type and was displayed at the Zhuhai air show in 2010, but without such close access.

Photographs show at least four versions since China began working on armed Z-9s in the 1980s. Differences are apparent in the sensor fit, pylon shape and door arrangements.

What seems to have been the earliest version retained the original three doors on each side of the body and had simple weapons pylons. An improved version sported an optical sight on the roof above the cockpit. These two versions may have been subvariants of the Z-9W. About 80 units were reportedly built from 1987.

Later an electro-optical ball turret under the nose replaced the roof-top sight—producing a version that has been identified as the Z-9WA—and finally the body was redesigned, with an arrangement of two doors on each side and beefier pylons. That was the version identified as the Z-9WZ at Tongzhou. "WZ" presumably stands for *wuzhuang*, meaning "armed."

EUROCOPTER

Show and Tell

Europe targets U.S. military market with X3 high-speed helicopter demo

Graham Warwick Manassas, Va.

EADS's plan to grow in the U.S. defense market may have been set back by losing the bruising tanker battle to Boeing, but the European giant has other weapons at its disposal. And in the company's arsenal, Eurocopter is as powerful a force as Airbus.

Now the company is aiming at the Pentagon again, in the form of Eurocopter's X3 high-speed helicopter demonstrator. The proof-of-concept X3 arrived in the Washington area last week on the final leg of its U.S. tour, with flight demonstrations from Fort Belvoir, Va., and a static display at the Pentagon.

EADS North America is considering proposing the X3 for the U.S. Army's Joint Multi Role (JMR) advanced rotorcraft technology demonstration, as a step toward competing for the Army-led Future Vertical Lift (FVL) initiative to replace thousands of helicopters with a family of advanced rotorcraft sharing common technology.

Eurocopter already is building the U.S. Army's UH-72A light utility helicopter, based on its commercial EC145, and hoping for a chance to compete for the service's Armed Aerial Scout requirement with a derivative, the AAS-72X. But FVL is an opportunity of a different magnitude—and timescale.

The Army is aiming to begin replacing its current fleet of helicopters in 2030, starting with the UH-60 Black Hawk. To meet that date, prototypes of an advanced medium utility rotorcraft have to fly soon after 2020. But first EADS must win a place on the Army-led JMR program, which plans to fly technology demonstrators in 2017.

Increased speed and range are among the attributes sought for the FVL, and the X3 "is suited to missions requiring high speed, long transit and hover flight," says Marc Paganini, president and CEO of American Eurocopter. The compound helicopter, which has wing-mounted propellers in addition to the main rotor, has reached 232 kt. in level flight, 50% faster than conventional helicopters, using only 80% of available power.

The X3 has conventional rotor and variable-pitch propellers driven from the same main gearbox and engines.

Eurocopter's goal is to increase speed 50% with a maximum increase in life-cycle cost of 25%, while retaining the low-speed maneuverability of a helicopter. But EADS is not yet a player in JMR. AVX Aircraft, Bell Boeing, Boeing, Sikorsky and a government team are completing concept design and analysis studies for the medium utility FVL, which will determine the requirements for the JMR demonstrators.

"We are very interested in FVL," says Steve Mundt, vice president of business development for EADS North America. "Stay tuned as the government completes its paperwork." The paperwork is expected "to be done by December, then they will put out a fact-based BAA [broad area announcement] with the performance criteria that we need to look at [for the demonstrator]," Mundt says.

The proof-of-concept X3 was built using parts of other Eurocopter products, including EC155 airframe and main rotor, EC175 gearbox and NH90 engines. While the demonstrator weighs 11,500 lb., the X3 concept is scalable from 13,000 lb. gross weight to "much more" than 31,000 lb., says Mundt. Today's UH-60M weighs 22,000 lb.

The FVL initiative also envisions replacing the Boeing AH-64D Apache, as well as lighter and heavier rotorcraft, including eventually the Bell Boeing V-22 Osprey tiltrotor.

The X3 concept is suited to the attack mission, Mundt says, because of its ability to accelerate and decelerate in a level attitude, point the nose up or down in flight and to control speed in a dive using the propellers. "Do we have an opportunity to compete in JMR/FVL? I think this can do it," he says.

Technology Denied

Lack of funding will keep key weapons in the laboratory

David Fulghum Washington

There are many breakthrough warfighting technologies available to U.S. Air Force planners, but perhaps only 10-20% of these projects have any chance of being funded for the foreseeable future.

Among the concepts are weaponry—both kinetic and directed energy—to intercept ballistic missiles as they launch and to attack low-orbiting space objects. There also are warheads that destroy, befuddle and misinform enemy electronics. They come in various sizes to fit 1-ton bomb casings, cruise missiles and long-range air-to-air missiles. Cybersurveillance devices and weapons are already being introduced into the service's arsenal; but as their sophistication goes up, so does the price. The brakes are already being applied to all of these and other advanced concepts. Even so, the Air Force had the largest cybersecurity budget of any of the services at $622 million for fiscal 2011, or 34% of the Pentagon's $1.82 billion total for that year.

"After an early period of substantial aspirations [particularly in cyber-activities], we have recalibrated," says Air Force Chief of Staff Gen. Norton Schwartz, who is slated to retire in August. "That's in part the recognition that this is a mission area that will take time and expertise to do well."

It is also a result of a decision to concentrate first on traditional air force missions. Demonstrations such as the service's Suter experiments have already proven that a data beam can be formed on an aircraft, filled with malicious algorithms and then fired into an antenna attached to a networked enemy defense system. The invasive code can show what enemy sensors see, take over as system administrator and invade outlying parts of the network through wireless communications links.

"Integrated air defenses are an area of [Air Force] interest," says Schwartz. "There are various ways to engage in that. Some are kinetic [bombing] and some, perhaps increasingly, are non-kinetic."

U.S. AIR FORCE FILE PHOTO

Gen. Norton Schwartz, Air Force chief of staff

Those options include the use of cyber-, electronic-attack and directed-energy weapons. In addition to technology, some of the capabilities are related to intelligence preparation of the battlefield, as well as tactics, techniques and procedures. Nonetheless, high-power microwave (HPM), cyber-, boost-phase-intercept (BPI), anti-satellite (Asat) and electronic-attack weapons could all move forward as tactically useful devices, but the expense is proving prohibitive.

"I think we are going to have to be selective for a while," Schwartz says. "This is clearly an area for [science and technology investments], but while in the past we could pursue five or six applications, now it will be one or two. HPM clearly has potential. There are others [such as Russia] that have done more in these areas than we have. Clearly this is an area for continuing efforts. The Air Force will be part of that."

The mass legislation needed to allow cybercombat to become a useful weapon is growing at about the same rate as the budget is shrinking.

The Air Force's chief scientist, Mark Maybury, says, for example, that a road map to forecast threats, develop operational capabilities and field a cyberworkforce will not be in place before mid-2014. USAF's efforts are supported by Cyber Flag, which is dovetailed with the Red Flag combat training program.

"But right now, we don't have good [cyber] situational awareness even though we haven't found a mission that is not dependent on cyber, and there are 50 zetabytes of data on the Internet," says Maybury. "Cyberoffense is industrialized, while defense is a cottage industry."

Moreover, he acknowledges the vulnerability of some of the Pentagon's best sensor systems to cyberattack and disruption, particularly the active, electronically scanned array technology that equips aircraft such as the F-35, F-22 and B-2. Critical analyses of these systems is urgently needed, since the Air Force has already demonstrated that a databeam packed with malware designed to take control of a network can invade networks through the face of a radar.

In fact, budget choices are already being made. The Mk. 84 bomb project has fallen by the wayside for now. Part of the decision was based on the available power sources.

"There is more to [directed-energy applications] than meets the eye," says Schwartz. "It deserves continued effort at Eglin [AFB, Fla.], Kirtland [AFB, N.M.] or the National Laboratories. [The Champ cruise missile with an HPM warhead] is a little bit further along. It's likely to have longer legs. It fits into the A2AD [anti-access and area denial] construct. AirSea Battle served as a furnace for thinking about more contested scenarios after a decade of operation largely in benign air environments. It reignited the notion that not all scenarios are going to be uncontested."

The BPI and Asat missions—plus the longer-range, higher-speed interceptor missiles and advanced warheads and sensors that go with them—will also receive attention again.

"We favor and recommended to the Missile Defense Agency and other partners that air-launched, hit-to-kill [technology] is a reasonable part of the air defense scenario," says Schwartz. "It's a resource-restricted environment, but as we look toward the vari-

ous elements of [MDA's] portfolio, we think there is a place for it. The command-and-control, sensors and kill mechanisms associated with hit-to-kill are not that much different from conventional air defense missions.

"Although hit-to-kill is based on traditional kinetic destruction, the capacity to disable or immobilize a target may serve our purposes," says Schwartz. "HPM isn't the only modality. Cyber and clandestine special operations fall into that arena. There are times you want your fingerprints to be obvious. Sometimes you want there to be some uncertainty about the source."

Advances in cyber-intelligence, surveillance and reconnaissance (ISR) are escalating, but demand for the product and costs are growing even faster.

The Air Force considers cyber-ISR as a venue not unlike signals, electro-optical or radar-based collection. Planners want the information effectively digested and correlated with other sources and intelligence-collecting technologies. But the information flow has grown so large that manpower—as it is applied now—has become an obstacle to efficiency. The service has more than 5,000 people in its exploitation and dissemination process. They examine 1,000 hr. of full-motion video a day and spend another 500 hr. working with data collected by other air-breathing platforms.

"For the last 10 years, we have devoted airmen's eyeballs to high-definition television to pursue tactical objectives," says Schwartz. "We will have to move beyond that kind of brute-force approach by increasingly automating analysis work or at least cuing the highest-value products for human review. I think we need to help them better focus their human capabilities on things that require human judgment."

The technology to reduce manpower needs is available, he says, but it has to have some devoted attention from planners and decision-makers. The Air Force has 20,000 or more people doing ISR, and that's about 10% of the operational force.

Perhaps cyberoperations will escape future defense funding cuts.

"In this budget environment, the absence of reductions is a signal of priority," says Schwartz. "It's still predominately based on defensive cyberoperations, but where it applies to Air Force missions, offensive capabilities are there as well."

Hackers Versus Cyberwarriors

The 'lone wolf' cannot compete against integrated cyberteams

David Fulghum Tel Aviv and Washington

Israel and the U.S. military have drawn similar conclusions about how to choose their cyberwarriors; however, the Israelis appear to be establishing a lead in identifying and training their electronic special forces.

DAVID ESHEL/AWST FILE PHOTO

Israeli Air Force Maj. Gen. (ret.) Itzik Ben-Israel trains his country's top cyberwarriers.

The conundrum can be illustrated by a sports metaphor. It involves distinguishing the erratic, eccentric, superstars from the organized, focused geniuses. Both can be naturals. But only one type can lead a team in tackling a problem so huge that it requires many teams working simultaneously to solve its interrelated parts.

Neither Israeli nor U.S. officials will speak publicly about who developed the destructive Stuxnet cyberworm or the Flame intelligence-gathering malware that has been derailing Iran's nuclear weapons development. But the effort involved a specialized kind of team play. Background discussions further reveal an operation that was heavily U.S.-funded and -backed with Washington's intelligence resources. That strategy was applied to a long-term project developed by professionals from both countries whose activities were protected by Israel's unique laws for maintaining the nation's security.

However, both countries face hurdles in finding staff and conducting advanced training for such cyberops. Officials concede the need for a better, earlier, screening system to identify the right people to become cyberwarriors. There is at least one element on which both countries agree. The intellectually arrogant, lone-ranger hacker is not the gold standard for innovative, multi-faceted cyberoperations.

"You have natural, imaginative hackers that apply their brilliance in 360-degree shot patterns," says U.S. Air Force Chief of Staff Gen. Norton Schwartz, who is slated to retire in August. "Then you have others, equally brilliant, that are more like engineers who apply [their unique skills] in a way that is more predictable, measurable and easier to manage."

That analysis underlies a decision made four years ago to put cyberoperations into Air Force Space Command.

"The judgment is that space and cyber are fundamentally engineering disciplines and that there are real similarities," says Schwartz. "We are less about innovative products than we are about outcome-driven capabilities. We will continue to lean in the direction of more engineering-focused talent. That's the path we'll stay on. The intelligence community might be in a different place."

Israel's effort to identify its cyber-manpower pool began at least 15 years ago with the establishment of an organization that one of its founders, Israeli Air Force Maj. Gen. (ret.) Itzik Ben-Israel, will not name; nor will he reveal the number of people involved. He is currently the chairman of Israel's space agency and a leader of the country's cyber effort.

IAI's long-range Heron TP could be a key element for cyber-reconnaissance and -exploitation.

However, another senior Israeli official said the number of recruits with these "very special traits" is "a couple of dozen a year who are picked from the "top 1/1,000th" of the country's students. There are some U.S. students in the program. Generally, top students are required to have fluent language skills in both Hebrew and English.

The cyberprogram is one of roughly 10 Israeli organizations that select and recruit 17-18-year-olds for specialized educations and training. A few are known. Talpiot (Hebrew for "high tower") trains specialists in physics and mathmatics. Psagot ("mountain peak") focuses on physics and electronics engineering. Graduates of these related programs already fill many of the top ranks of Israeli industries.

About two years ago, Ben-Israel was appointed by the prime minister to lead a team of experts to help organize a new office—the National Cyber Headquarters. Its new leader is a graduate of the Talpiot who is encouraging the universities to conduct more research in cybertechnology.

"The cyberspecialty for Israel is not new," says Ben-Israel. "It became popular after the Russian attack on Estonia in 2007. But we started to be engaged at the beginning of the 1990s, when we realized how vulnerable a modern state is—not just its defenses, but power-production, food supplies and banking. Those institutions are in the private and business sectors, so the government decided to build a new agency in 2002 that would be in charge of protecting critical, private and civilian infrastructure."

In contrast, the U.S. does not have that kind of protection.

"In Israel we solved it, because threats are visible and concrete," Ben-Israel says. "People are more willing to give up some of their civil rights to be more protected. We've had those laws for 10 years. In the U.S., they don't see the threats as real."

Another part of the solution could be an international Internet police to monitor for crime and abuses.

"You need international cooperation," he says. "Who are the bad guys? You have to answer that question."

Israeli officials start the screening process for the technologically talented to staff the cyber-organization—just as the military screens for its fighter pilots—at 17 years of age.

As a result, "we have an advantage that no one else does," he says. "Everyone has to go to military service, so we can screen everyone. But even though the screening is complicated, it is not complete. There are kids who have been working with computers since they were 11 or 12 years old. But they don't know how to work with other people. They sit at their computers and don't go out. Their friends are virtual friends."

U.S. and Israeli officials are both looking at the idea of beginning the screening and development of candidate cyberspecialists as early as 13-14 years of age.

Schwartz agrees that a good time to start cultivating the cyber-talented is around Grade 7, when computer and math skills start to emerge. An Israeli lawmaker tells Aviation Week that the government needs to reach these youngsters before they can be recruited by crime organizations or other countries' intelligence agencies. "We are collaborating with the Navy to develop an assessment of the potential of individuals [and] to predict the success of cyberoperators," says Mark Maybury, the U.S. Air Force's chief scientist. "I suspect there are some general properties that we will discover are necessary. We should know this within the next year. You can definitely tell which kids enjoy it. Having a passion about a subject is as important as innate talent. What you need are individuals and teams that can think holistically about defense, whether it be in cyberspace, space or air operations. That's the kind of talent the military will need."

A military cyberproject is not the product of one person. The work on big projects is divided among groups; each is responsible for one portion. The project has to be coordinated through the effort of many people. It took Israeli researchers about three years to figure out the formula.

"Intellectual skill is not enough," says Ben-Israel. "You need social skills and values. [For the 'lone wolf' type] breaking into the Pentagon's central computer is a game, a challenge, and sometimes they don't have the necessary judgment. You need values to distinguish between good and bad—what's allowed and what's forbidden. In the beginning we had some failures."

At least one former recruit is now in jail in North America for cybertheft. Ben-Israel looked to his favorite philosopher—Immanuel Kant—for guidance. His books discuss the attributes of a complete person—pure reason, pure judgment and practical reason, the third element being the realm of ethics and values.

"That's what we look for when we screen those kids," says Ben-Israel. "We begin with their high-school marks and discussions with their teachers. Then we invite them in for a series of tests and interviews, and select some of them. They have to have the right set of values. That's what we look for."

Israeli lawmakers acknowledge that a new battlefield—cyberoperations—is opening up, and they may have to recruit younger. But they also worry that such people will be isolated from actual combat and the threat of wounds or death. That omission, they worry, will be an unfair advantage that a normal military person does not have. Several government papers on the subject are in circulation.

"There is a moral question of equality," says an official with insight into Israel's cyberprograms.

As a possible gauge of national cyberskill, a U.S. cyberprotection company recently gave out marks for cyberreadiness to many countries. Sweden, Finland and Israel received the highest marks; Russia and the U.S. were in the second tier, and China was in the third.

ISRAEL AEROSPACE INDUSTRIES

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Industry segments are questioning FAA's lack of 757 data for its proposed safety upgrade.

Freighter Fight

FAA's fuel tank risk about-face meets opposition

Sean Broderick Washington

Operators and OEMs are lining up against the FAA over a proposed Boeing 757 airworthiness directive (AD) that they see as an unsubstantiated shift in the agency's view on the likelihood of fuel tank explosions on older freighters—a change that could have broader rulemaking ramifications.

FAA's draft rule, issued in March and reopened for public comment last month, calls for modifying either fuel quantity indication systems (FQIS) or center tanks to eliminate potential ignition sources. The directive would apply to U.S.-registered 757s not covered by the agency's 2008 fuel tank flammability reduction (FTFR) rule—in other words, freighters and aircraft operated under Part 91. FAA proposed a five-year compliance window at a cost of about $200,000 per aircraft, although the agency admits that it lacked solid retrofit cost data.

Industry is challenging practically everything in FAA's draft, down to the agency's basis for proposing it. The FTFR rule, issued as part of a revamp of transport category fuel tank system design and maintenance standards following the 1996 inflight explosion of TWA Flight 800, ordered flammability reduction means (FRM) for several passenger aircraft, including the 757. The FAA said that while the rule would apply to new freighter designs, the agency lacked sufficient data to justify cargo retrofits, adding that it would "continue to gather additional data" on in-service freighter fuel tank explosion risk, and "may initiate further rulemaking action if the flammability of these airplanes is found to be excessive."

Four years later, the FAA recalls its 2008 take on future fuel tank safety rulemaking differently. "As discussed in the FTFR rule," FAA says in the 757 notice of proposed rulemaking (NPRM), "the agency recognized that separate airworthiness actions would be initiated to address the remaining fuel system safety issues for airplanes for which an FRM is not required."

If new data influenced FAA to revise its 757 flammability risk assessment, the agency didn't include it in the NPRM. The draft rule cites directives issued for 747 Classics and 737 Classics in 1999 and 1998, respectively, mandating modifications that separate FQIS wires from higher-powered wires and circuits. The references suggest that, absent a flammability reduction system, the 757's FQIS and center fuel tank configuration poses the same unsafe conditions as these two models, which, due to their ages, were exempted from the FTFR rule. However, Airlines for America notes in comments filed to the rulemaking's docket (FAA 2012-0187) that FAA "gives no indication" that its revised position on 757 fuel tank risk is based on new data.

Airbus, fretting over FAA's intention to target some of its models, echoes the trade group's take in its comments: "The NPRM does not provide any data showing that the level of fuel tank explosion risk has increased for the concerned aircraft models since 2008."

FAA acknowledges in the NPRM that it plans "similar actions" for Airbus and Boeing aircraft with "similar FQIS vulnerabilities." If that's the case, Airlines for America notes, FAA should pursue a broader, FTFR-like rulemaking complete with both cost-benefit and risk analyses, rather than relying on the "less rigorous" AD process.

Goodrich, which roughly split the 757 FQIS market with Honeywell, tells FAA that its system has not had any failures in service that caused the fuel tank to be unsafe. The in-service data, along with Boeing analysis, "[raises] the question of why this proposed rule is required," Goodrich adds.

Factoring in the freighter fleet's operational profile lowers the risk even more. Referencing the Cargo Airline Association's 2008 FTFR rule comments, Boeing notes that freighters typically fly at night and use air-conditioning packs less often than passenger carriers. This keeps center fuel tank temperatures lower. Given the shorter average segments 757 freighter operators fly—meaning less need for fuel—and the risk of fuel tank flammability exposure could be as much as 50% less for 757 freighters than their passenger-hauling counterparts, Boeing calculates.

Proposed compliance options—either a new FQIS or a tank modification, or in the 757's case, a nitrogen-generating system (NGS), provide challenges. Boeing says developing a new 757 FQIS isn't practical. It plans to offer 757 cargo operators the NGS developed for its passenger model. "Boeing is NOT advo-

cating the mandating of FRM on these cargo or Part 91 operation aircraft," the OEM underscores, "but we do not believe an FQIS redesign is necessary for this extremely improbable risk." This, notes UPS, would mean that cargo operators would be forced into de facto compliance with FAA's 2008 rule—a scenario that "disregards the fact that the all-cargo aircraft category for NGS installation fell out of the cost-benefit analysis of the FTFR rule."

The NPRM's only comments supporting the directive come from the National Air Traffic Controllers Association, which recommended a compliance time of three years and said the rule should apply to all 757 fuel tanks. Its justification? A 2008 AD that requires all new 757 wiring to be separated from FQIS wiring. Several pilots unions supported making the 2008 FTFR rule applicable to freighters, but none have filed comments on the 757 proposal.

Smart Growth

Expansion pays off for Hawaiian

Adrian Schofield

Hawaiian Airlines is continuing to buck U.S. industry trends by aggressively ramping up capacity, as it looks for new opportunities not just on the Pacific Rim but also on its own doorstep.

Growth exceeding 20% is almost heretical in the industry's new religion of capacity discipline. But Hawaiian is proving to be one of the rare airlines that can expand quickly and still improve its financial performance.

The carrier's long-haul growth is driven by the delivery of new Airbus A330s, enabling it to open routes to New York, North Asian markets in Japan and South Korea, and to the South Pacific. Another new development sees Hawaiian focusing on the other end of the fleet scale, with a plan to launch a turboprop subsidiary for inter-island service.

The addition of Airbus A330-200s is giving Hawaiian Airlines more international options.

Hawaiian boosted its capacity by 16.8% in the second quarter, and it predicts full-year growth of 21-24%. While this may seem risky in uncertain economic times, it has also increased unit revenue and yield by healthy margins. The airline has recorded four straight profitable quarters despite the challenges of opening new markets.

Not everyone is convinced about the pace of growth, however. In a recent earnings call, Hawaiian CEO Mark Dunkerley admitted that Wall Street analysts are divided about the merits of launching direct flights between Honolulu and New York, the carrier's first foray to the U.S. East Coast.

But Dunkerley says the New York route is already showing very promising signs since its June debut. Forward bookings are stronger than for other U.S. mainland destinations, and the new route is performing better than the company's internal expectations.

During the analyst call, in response to a question about whether Hawaiian can handle the launch of a regional subsidiary simultaneously with the long-haul expansion, Dunkerley replied that this new operation—which will have up to six turboprops—will be too small to materially affect systemwide costs, revenue or profitability.

He also says the new unit is not aimed at merely increasing capacity, but at filling gaps that exist in Hawaiian's inter-island network. It will fly to small markets that cannot be served—for economic or operational reasons—by Boeing 717s, currently the carrier's smallest aircraft.

Hawaiian has not yet set a start date for the turboprop operations, although it has signed a letter of intent with an unidentified party covering the acquisition of turboprops. The aircraft are used, and will be owned rather than leased.

The aircraft type is also not being revealed. The carrier's collective bargaining agreement restricts turboprop operations to aircraft with no more than 69 seats, and Hawaiian believes 50 or fewer seats is the right size for the markets it has in mind.

On the long-haul front, Hawaiian has either launched or announced eight new routes since November 2010. All except the New York service are to Pacific Rim international destinations.

One aim of this international push is to reduce the carrier's reliance on its traditional core business, flights from U.S. West Coast cities to Hawaii. These now account for 47% of overall revenue—still the largest segment, but down considerably from a share of almost 70% just five years ago, Dunkerley says.

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Hawaiian took delivery of three A330-200s in the second quarter, and now has nine in its fleet. It is due to receive five more next year, out of a total of 13 slated for delivery between 2013 and 2015. While its Boeing 767-300ERs are used on some international routes, the A330s have been the spur for long-haul growth.

The airline's main focus for international expansion has been North Asia, but lately it is turning its attention to the South Pacific. Hawaiian will begin three times weekly service to Auckland, New Zealand, in March, following the introduction of three weekly flights to Brisbane, Australia, in November 2012. It already operates to Sydney, and this route was increased to daily in December 2011.

As things stand, Hawaiian will be the only U.S. carrier serving New Zealand directly when it launches the Auckland route. The service will connect to Hawaiian's inter-island and U.S. mainland networks, opening up one-stop options to New Zealand from multiple U.S. cities.

Dunkerley tells Aviation Week that the Hawaiian fleet is fully committed through the first quarter of 2013, but there will be scope to add new long-haul destinations from the middle of next year.

More With Less

Small satellites gaining users as capability and applications increase

Frank Morring, Jr. Washington

Small satellites, once the realm of one-off low-budget science missions and undergraduate engineering classes, have come full circle with the growing realization among hard-pressed, high-end users that the little birds can do the big jobs, too.

NASA AMES RESEARCH CENTER

TechEdSat is scheduled to be the first U.S. cubesat deployed from the International Space Station.

For additional photos and the latest on smallsats, check out the digital edition of AW&ST on leading tablets and smartphones, or go to **AviationWeek.com/smallsats**

The smallest of them—cubesats—are rapidly evolving into an operational commercial, scientific and military technology. Higher up the payload-weight scale, the high cost per pound of launching payloads and the growing skill of spacecraft miniaturizers are making satellites that are small enough to ride as secondary payloads attractive to a variety of customers, particularly if they can be mass-produced or produced rapidly in single units.

The launch-cost consideration may change, as the growing interest in small spacecraft attracts a new generation of small launchers designed to carry them. And the spacecraft themselves are increasingly capable, with government money flowing into the arena in search of a way to do more with less.

"From where we have been 10 years ago to where we are now is a complete 180," says Roland Coelho, a member of the research staff at California Polytechnic State University's engineering school, one of the main U.S. centers for cubesat development. "In the past it's been primarily educational. . . . As we have kind of grown—the entire community worldwide over the past decade—we really have started to see some niche markets where cubesats can play a vital role. It's clearly the most evident in the government cubesat programs that we have today. The government, and particularly the U.S. government, has been the driving force in this technology because that's where all the funding is."

Government interest in small satellites is not limited to cubesats, or even to spacecraft. The U.S. Defense Advanced Research Projects Agency (Darpa) is spending $46 million to find ways to launch satellites weighing up to 100 lb. on 24-hr. notice for less than $1 million (see p. 44). And the Air Force and National Reconnaissance Office consider small satellites a way to lower risk in national security spacecraft by adding redundancy in orbit.

"Even if 20% of them failed, you'd still do your mission, so there's sort of a natural resiliency in using constellations of smaller satellites," says John Roth, whose company—Sierra Nevada

Space Systems—makes small satellites for the military and others. "One of the advantages that the military recognizes also is, if we're worrying about countries taking offensive action against our satellites . . . the more satellites you have up doing the same mission, the harder it is for them to do anything to our satellites."

Building more, smaller satellites also lowers the cost of each bird through mass-production economies of scale. This fall, SpaceX is set to launch the first of 18 second-generation low-Earth-orbit narrowband satellites that Sierra Nevada is building for Orbcomm.

"They contracted with us $117 million for 18 satellites, so that's a unit cost of about $6.5 million a satellite," says Roth. "And if you look at what a typical NASA or [Defense Department] mission costs, you can't come anywhere close to that."

Compared to cubesats, however, even that is a high pricetag. With a standardized "1U form factor" measuring 10 cm (4 in.) on a side and weighing no more than 1.33 kg (3 lb.), cubesats typically cost well below $100,000 to build and launch. Coelho has seen changes in the technology first-hand, beginning in 2000 as a Cal Poly undergraduate working with cubesat pioneer Jordi Puig-Suari, and later joining the staff. Among the school's accomplishments is development of the standard cubesat deployment system—the Poly-PicoSatellite Orbital Deployer (P-POD)—and helping to advance the state of the art in cubesats to the point that they are being used to tackle serious science missions (see p. 41).

"It was a training tool for students to build a satellite within their academic career, from design to manufacturing and then to launch and then to on-orbit operations," says Coelho of the early days. "And it was a good way for small commercial companies to do technology demonstrations for certain components."

Now, with growing acceptance from users and from the launch-service providers who must weigh the value of carrying secondary payloads against the risk they pose to their primary missions, the ideas for using small satellites, and particularly cubesats, are piling up. One early area of U.S. Air Force interest is multi-source weather data.

"Because the cubesats are small, you can launch them in bunches and disperse them out [with] variable drag capability," says David Hinkley, a senior project leader at The Aerospace Corp. "Now you've suddenly got 10 useful satellites flying around in different positions that can take temporal data, data that changes with time. In the past they would fly one big satellite, and they would not able to be in multiple places at once."

Aerospace is experimenting with using the variable drag in low Earth orbit that cubesats get from deploying and retracting different combinations of cruciform solar arrays. NASA's Office of the Chief Technologist (OCT) plans to launch a constellation of eight 1.5U cubesats next summer in a project called the Edison Demonstration of Smallsat Networks. Its goal is to begin developing inter-satellite communications that could be applied to a number of different applications, including monitoring weather, ice cover in the polar regions and other Earth-surface conditions.

With its mission to push technology hard, Darpa is also working on a mission dubbed Phoenix that is aimed at recycling usable hardware from nonfunctioning satellites in geostationary (GEO) orbits by reactivating them with tiny modular "satlets" designed to perform various spacecraft functions. On July 12, the agency awarded Canada's MacDonald Dettwiler a contract worth as much as $2.1 million to begin developing systems that can revive a usable antenna on an out-of-service GEO satellite.

At the other end of the satellite service life, NASA's Marshall Space Flight Center is building on its work with NanoSail-D—a 100-sq.-meter (1,075-sq.-ft.) solar sail demonstration that deployed on Jan. 21, 2011, from a 3U cubesat—to develop deployable drag sails to pull obsolete smallsats out of orbit instead of adding to the space-debris problem.

Overall, Darpa plans to spend $36 million on the Phoenix project, which is peanuts by U.S. military standards. But it is big money in the smallsat world, where mass production and standard forms continue to cut hardware costs dramatically. A San Francisco-based company—Pumpkin Inc.—is selling cubesat kits starting at $7,500 that can be customized depending on the capabilities needed. To date, more than a dozen have been launched, according to Andrew Kalman, the company's president and chief technology officer, who says Pumpkin is following the Apple Inc. model.

Tiny electrospray thrusters (top) enabled by MEMS emitters (bottom) could solve the cubesat propulsion problem.

"We want to make sure that cubesats really are one of the foremost places where you can leverage the continuing advance of technology," says Kalman. "To do that you need to recognize that you are not in the driver's seat when it comes to the technology you want to put up there. Rather, you need to be leveraging other markets which are in the driver's seat, which in this case is essentially the consumer electronics field, and take advantage of those technologies."

When Orbital Sciences Corp. launches its first Antares rocket from Wallops Island, Va., later this summer, it will be carrying three 1U cubesats that take the consumer-electronics approach to spacecraft to new heights. Wedged into one of them will be a standard Android smartphone, with a bunch of extra batteries, in a test of whether the open-architecture elec-

tronics and commercial hardware can survive in space.

"If the platform is open, if the operating system is open, well then, almost anybody could write an app that could do something that may be beneficial to spaceflight, so you can tap into that larger community of app writers," says Bruce Yost a project manager at Ames Research Center, where NASA's smallsat work is headquartered. "It kind of changes a lot of things that you do in aerospace."

Another "Phonesat" version carries the innards but not the case of the Android. The work, spearheaded at Ames with funding from OCT, is not limited to smartphone software, but includes such hardware possibilities as removing the weights from the phones' "vibrate" mode and using the motors as tiny reaction wheels, says Yost.

Despite the possibilities, some areas of smallsat technology still need work, particularly in the cubesat arena, where communications is a particular problem. The Phonesats set to fly on the first Antares mission will test the smartphone computing for spaceflight apps, but the radio will be switched off because it would not work in space. Instead, cubesats rely on ham-radio frequencies for links with the ground, and that limits both contact time and bandwidth.

To tackle those problems, experts at the European Space Agency are developing an international ground-station network called the Global Educational Network for Satellite Operations (Genso), which is basically a set of software and protocols that will give cubesat operators a worldwide network of ground stations (see map).

At Ames and California's San Jose State University, preparations are underway to begin operating the Technical and Educational Satellite (TechEdSat), which was launched July 20 on Japan's third H-II Transfer Vehicle. Based on a Pumpkin cubesat-kit structure, the 1U cubesat will become the first U.S. spacecraft to be deployed from the International Space Station (see p. 44)..

Inside are three radios—a Stensat Radio Beacon transmitting with 1 watt of power at 437 MHz, and modems designed for Orbcomm and Iridium low-Earth-orbit communications satellites. Because of licensing issues, only the beacon will be operating during flight, but San Jose State students have already demonstrated that the Iridium and Orbcomm hardware can be integrated into a 1U cubesat, and powered with batteries approved for safety by NASA's ISS program office at Johnson Space Center.

Communications is one of three areas in smallsat technology that will be flight-tested with new funding from NASA. The agency's chief technologist received a heavy response to its request for proposals in communications, proximity operations and propulsion, and expects to make selections for the 2-3-year effort before the end of August.

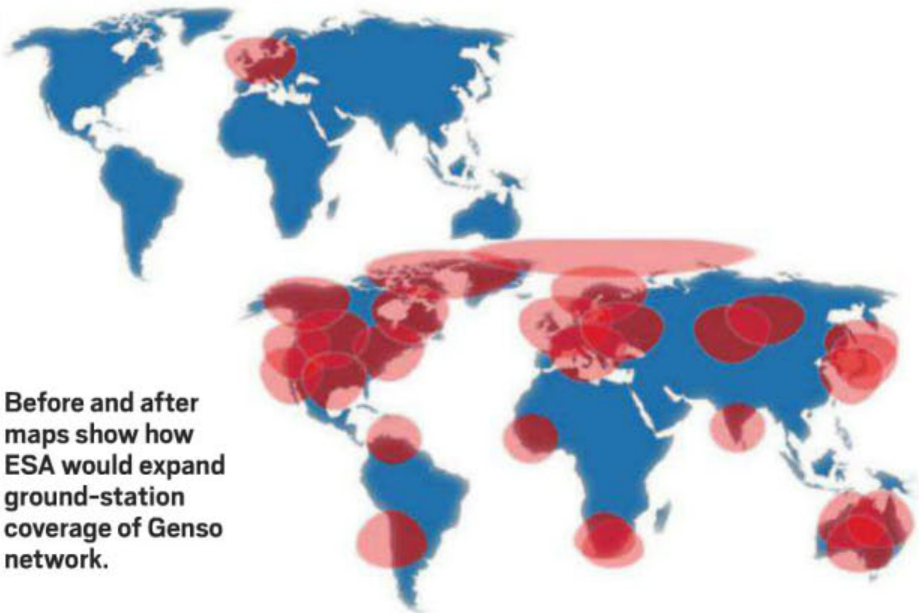
Sensors, software and thrusters for proximity operations could enable tiny inspectors to fly safely around larger spacecraft—including the ISS—to routinely document their physical condition and pinpoint debris damage or mechanical problems soon after they occur. Some of the software work is already underway inside the station with the Synchronized Position Hold, Engage & Reorient Experimental Satellites (Spheres) control-software testbeds: three volleyball-sized balls designed to give programmers a quick check of their algorithms in microgravity (*AW&ST* June 25, p. 44).

Because of the size and safety limitations that launch-service providers impose on secondary payloads, propulsion has been a particularly difficult problem for small-spacecraft designers, with the difficulty increasing as the size decreases. The Swedish Space Corp.'s NanoSpace unit has used micro-electromechanical systems (MEMS) fabrication technology to develop miniature thrusters that have been tested in orbit on the Prisma satellite testbeds (*AW&ST* May 7, p. 21).

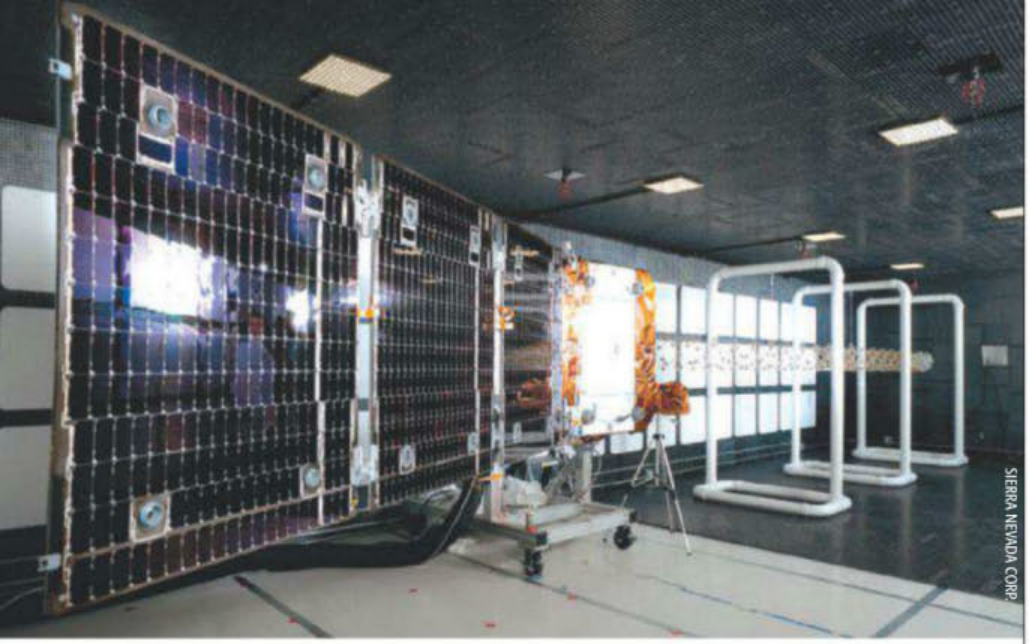
At least one proposal in the OCT competition involves an update on the colloid thrusters tested in the 1960s and '70s and dropped in favor of ion propulsion because they just did not work as well. But now, says Paulo Lozano, an associate professor of aeronautics and astronautics at the Massachusetts Institute of Technology, advances in propellant chemistry and MEMS production is enabling development of "electrospray thrusters" that emit ions when subjected to an electric charge, instead of the heavier droplets emitted in the older technology. Using coulomb liquids—electrically conductive liquid salts composed of molecular ions—wicked by capillary action through a plate of tiny emitters produced with proprietary MEMS techniques—the thrusters produce a spray of ions when an electric charge is passed across them. The approach eliminates the need for pumps, valves and other moving parts, and generates specific impulses of 1,500-5,000 sec., depending on the propellant.

"It basically works like a candle," Lozano says, noting that the thrusters operated with 80% efficiency. "The 'wax' of the candle is the propellant, and the 'wick' is just the transport medium, and the 'flame' is the thrusting mechanism. So it's very similar, except that we evaporate ions, and in the process of evaporating the ions we also

ESA



Before and after maps show how ESA would expand ground-station coverage of Genso network.



Mass production of smallsats lowers costs, as with this $2.5 million second-generation Orbcomm bird.

accelerate them to very high speeds."

In the longer term, engineers are studying ways to combine spacecraft so a small satellite can disperse cubesats after launch and then serve as a "mother-ship" communications hub. NASA's Nanosail-D flew to orbit in a P-POD inside the agency's Fast, Affordable, Science and Technology Satellite (Fastsat) developed by Dynetics as a way to get payloads to orbit on a free-flier in fewer than two years after authority to proceed. With the solar-sail demonstration, it also showed that a larger spacecraft can safely jettison a smaller one.

Now the Huntsville, Ala.-based company is looking for new uses for the Fastsat capability.

"The Communications Relay for the Arctic Domain is the next generation of that concept, where we would actually be a mother ship and deploy multiple cubesats to fly in formation with Fastsat and provide a larger coverage ring," says Mike Graves, manager of the Space Vehicles Department at Dynetics. "So you have the host mother ship in the middle and then you've got in formation flight maybe four 3U cubesats, each one of those having its own localized communications capability and sensors, and then you send it back to the mother ship for the large data bandwidth to the ground."

Continental Constellation

Europe building on its pioneering smallsat work with advanced birds

Amy Svitak Paris

Europe has long been a hotbed of small-spacecraft development. Now investments in the U.K., France and Germany are paying off, and an increasingly sophisticated fleet of smallsats is being used for Earth observation, science and military applications.

Next year the European Space Agency (ESA) is preparing to launch its Proba V satellite atop the new Vega light launcher from the European spaceport at Kourou, French Guiana. The 160-kg (352-lb.) microsat is based on the agency's Proba technology-demonstration platform, but is designed to fly an operational payload that will monitor global vegetation growth.

Current vegetation monitoring instruments aboard France's Spot-4 and Spot-5 satellites have mapped changes in worldwide vegetation to provide data on crop yields, droughts, desertification and deforestation. However, the two satellites are operating well beyond their design life, and no immediate follow-on capability is planned until ESA launches the Sentinel-3 Earth observation satellite in 2014 under the Global Monitoring for Environment and Security (GMES) program. To ensure data continuity in the interim, ESA and the Belgian Federal Science Policy Office are investing in a scaled-down version of the Spot vegetation-monitoring instrument that will fly aboard Proba V.

In France, the CNES space agency continues to rely on its lightweight Myriade platform for quick, low-cost science and technology demonstration missions. Weighing less than 200 kg, the Myriade bus was conceived in the mid-1990s as a complement to CNES's Proteus mini-satellite platform in the 500-kg class.

Developed with EADS-Astrium to serve as the space segment of a turnkey mission system, Myriade comes with a ground system for data acquisition and command-and-control, as well as tools for mission analysis, spacecraft design and system validation.

Since 2004, 17 Myriade-based microsatellites have been placed in orbit. The first, Demeter, was used to measure the Earth's magnetic environment and forecast earthquakes. The spacecraft was deorbited in mid-2010, leaving more than six years of scientific data on the link between ionospheric perturbations and seismic and volcanic activity.

Demeter was followed by Parasol in December 2004, a mission to study the properties of aerosols and clouds of the Earth's atmosphere, followed by the Picard solar-variability mission launched in June 2010.

Two additional CNES science missions—Taranis and Microscope—are slated to launch in the next few years. CNES recently signed a contract with Arianespace that would see Taranis lofted atop a Russian Soyuz or European Vega rocket in 2016 from Kourou. The 200-kg spacecraft, which is designed to study the magnetosphere-ionosphere-atmosphere coupling via transient processes, would be launched into a quasi-Sun-synchronous orbit at an altitude of 700 km (435 mi.).

In addition to Taranis, the contract includes an option to launch two additional satellites: Microscope, which will test the validity of Galileo's Equivalence Principle in the vacuum of space; and Merlin, a €120-million ($144-million) project funded by CNES and the German Aerospace Center (DLR) that will incorporate a German lidar instrument. Both na-

tions will collaborate on the payload ground segment and data analysis.

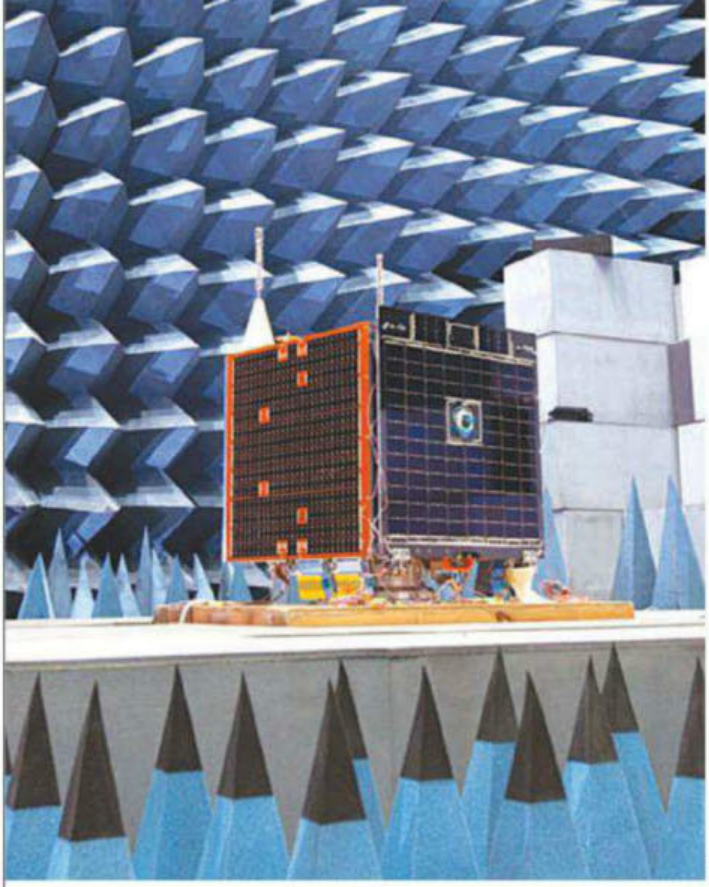
Slated to launch in 2016, Merlin will be the first of a second-generation microsatellite platform, dubbed Myriade Evolution, designed to boost spacecraft performance. The new bus, which is being developed with €40 million in French public bond money, is intended to double the current platform's 50-kg payload capacity and 50-watt power generation on orbit.

Following Merlin, France is planning to loft in 2018 a carbon-dioxide-monitoring satellite dubbed MicroCarb that will be based on the new Myriade Evolution platform.

France's armaments agency (DGA) is also using Myriade to experiment with formation-flying and swarming capabilities. The Astrium-built Essaim constellation, which launched with Parasol in December 2004, was designed to study the electromagnetic environment on the ground in military frequency bands with a swarm of four 120-kg spacecraft separated by a few hundred kilometers.

DGA's Spirale demo, developed by Thales Alenia Space and Astrium and launched in February 2009, comprises two satellites that collect infrared images of terrestrial backgrounds and serves as a precursor to development of a space-based operational early warning system in France.

More recently, CNES launched the Astrium-built Elisa electronic intelligence satellites for DGA in December atop a European variant of the Soyuz rocket from Kourou. The four-satellite demonstration cost €115 million to develop and launch, and is aimed at locating and identifying radar stations. The 120-kg satellites are operating in a polar, low Earth orbit at an altitude of 694 km, and could pave the way for an operational program.



SSTL

Among European smallsat advances, SSTL's exactView-1 undergoes electromagnetic interference testing. It will be the most capable Automatic Identification System spacecraft ever built.

Astrium, through its partnership with CNES, offers a commercial version of Myriade dubbed AstroSat100. Three missions based on the platform are currently in orbit, including Chile's SSOT Earth-observation satellite, which launched with Elisa last year; Algeria's two-satellite Alsat Earth-observation system; and a Vietnamese optical satellite, VNREDSat-1.

In July, DLR lofted its TET-1 satellite, the first in a series based on Germany's BIRD (Bispectral InfraredDetection) small-satellite platform that will support DLR's On-Orbit Verification program. Developed by Astro- und Feinwerktechnik Adlershof GmbH, the 120-kg spacecraft bus is loaded with 11 experiments operating in a Sun-synchronous orbit at an altitude of 500 km, including a camera capable of detecting forest fires.

While roughly the same size as the experimental BIRD platform, TET-1 is a more capable spacecraft for operational missions, says DLR Chairman Johann-Dietrich Woerner. "We now have TET-1, but hope to have more of these," he says. "In order to get better revisit time, we need more than one satellite to give us information as close as possible to real time."

TET-1 was one of five small satellites launched July 22 on a Soyuz rocket from Baikonur Cosmodrome in Kazakhstan. The others were two Russian Earth-monitoring satellites, Canopus-B and MKA-PN1; the Belarusian BKA spacecraft; and exactView-1, a Canadian maritime-monitoring spacecraft built by U.K.-based Surrey Satellite Technology Ltd. (SSTL).

A spinoff from the University of Surrey's space technology school, SSTL started out in the mid-1980s catering to nations in the market for small research satellites. Today SSTL is a booming business that is wholly owned by Astrium, and is building the payloads for Europe's 22 operational Galileo satellites to be lofted starting in 2013 (see p. 42).

Smallsat Savvy

Tiny planet-finder has sophisticated software, COTS elements

Frank Morring, Jr. Washington

A $5 million cubesat is definitely top of the line, but not when it is being developed to perform work similar to that underway on the $600 million Kepler planet-finder mission.

A group at the Massachusetts Institute of Technology (MIT) is developing a cubesat dubbed ExoplanetSat to evaluate whether any Earthlike planets found circling bright, relatively nearby stars have orbits that would permit spectral analysis of their atmospheres.

While the cost of the first planet-finding cubesat taking shape at MIT is high, its developers hope to be able to build enough of them to bring down the unit cost. Restrictions imposed by the tiny space available inside the 3U cubesat—measuring 30 X 10 X 10 cm—limit each to observing one exoplanet, so a "swarm" of "dozens" of spacecraft watching the same number of different stars would be needed, says Sara Seager, a professor of planetary science and professor of physics at MIT who is key to the work.

The $5 million 3U cubesat would use off-the-shelf hardware.

"Kepler is looking at faint stars that are by definition far away," Seager says. "We're trying to look at the brightest, nearest stars. The bright stars are spread all around the sky, and that's why a Kepler wouldn't work for all the brighter stars, because Kepler only looks at one patch of the sky. We need one telescope per star."

While Kepler is a survey instrument that stares at a tiny area of sky and measures the faint flicker that occurs when an orbiting exoplanet moves in front of it, ExoplanetSat will stare at a single star to gather as much data as possible from a transiting planet. Given the tiny change in the amount of light reaching the spacecraft's detector, keeping the light from a target star focused will require pointing accuracy at "the several-arcsecond level" if the noise level in the system is to be low enough to permit meaningful measurements.

Packing all that capability into a spacecraft only 30-cm long will require clever use of hardware—some of it off-the-shelf, as is typical of cubesats—and some really clever software. Gross pointing is achieved with miniature reaction wheels produced for the cubesat market by Maryland Aerospace Inc. of Crofton. These serve to point the spacecraft at the target star with an accuracy of 60-100 arcseconds, Seager says.

Light from the star is collected with a space-hardened off-the-shelf single-lens-reflex camera lens, and passed on to a detector that consists of a single charge-coupled device (CCD) surrounded by an array of several complementary metal oxide semiconductor (CMOS) detectors. Behind the detector plate is a piezoelectric actuator that moves it in the x and y axes (see schematic).

"We have a piezo stage; it's like an x/y control attached to the detector, which is where the focal plane of the telescope is," Seager says. "And then we move that around and that gets us from that 60 arcseconds down to several arcseconds."

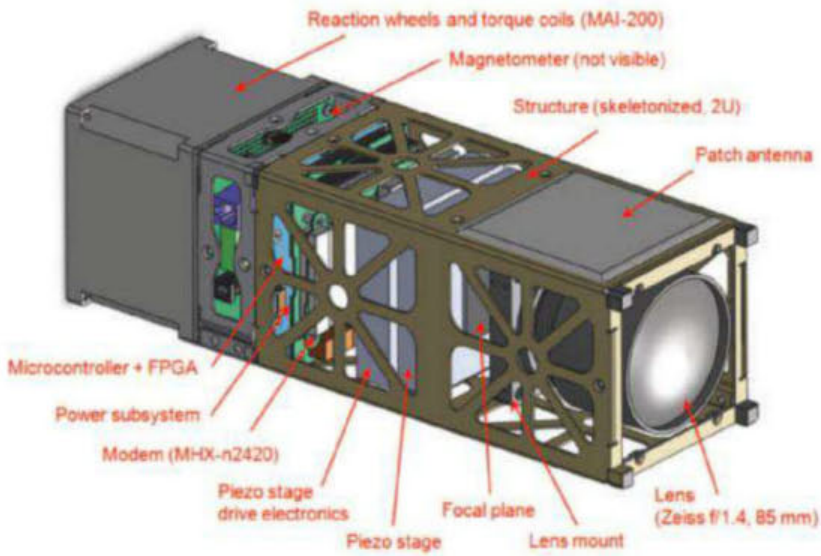
The hardware is able to move the detector by microns in the two dimensions, but Seager notes that there is nothing new in the general approach of using starlight to guide a telescope.

"It's common," she says. "That's basically how all telescopes are controlled. We're building upon things that we have done before. We're just trying to do it to a more precise level with smaller equipment."

So far, the MIT team has tested the spacecraft's precision-pointing function with breadboard hardware on an air-bearing table. The camera and imaging-electronics board are also in hand, and have been tested both in the lab and outside against the night sky.

Although the work kicked off with a little astrobiology funding from NASA, the main financial support has come from Draper Laboratory, an MIT spinoff, and from MIT itself.

"That brought us about halfway in terms of the money spent, because we spent a lot of time on R&D," says Seager.



MIT

"We're still looking for more money to finish the project now."

The MIT team has secured a launch, when the spacecraft is ready, via NASA's Educational Launch of Nanosatellites (ELaNa) program (see p. 44), and has a notional mission design and list of target stars. ELaNa payloads can't choose their orbits, but must follow the primary payload's route to space, so in general ExoplanetSat will go to an equatorial orbit in as low an inclination as possible, with an altitude that avoids the radiation belts to extend the lifetime of the detectors and other electronics.

"The field of exoplanets moves so quickly that by the time we launch, the list of targets will be different," Seager says.

Those targets will be bright stars identified from the ground as having planetary systems. ExoplanetSat will determine if its target system includes a planet that transits the star, which could allow researchers to determine its size and fitness for study with larger and more expensive spacecraft.

"We ultimately want to do direct imaging from space, but that won't be done with cubesats unless you get them to self-assemble into something much bigger," says Seager.

Standing Small

Smallsat maker Surrey Space Technology Ltd. (SSTL) has turned the business of building small, inexpensive science and research satellites into a thriving commercial enterprise that has nearly doubled its revenue since being purchased in 2009 by EADS-Astrium, Europe's largest space hardware manufacturer.

SSTL Executive Chairman Martin Sweeting started the company in 1985 with a staff of four and the equivalent of about €100 ($121 at today's rates). In July the company lofted its 37th spacecraft, a 100-kg (220-lb.) maritime surveillance satellite built for Canadian startup exactView, an example of how SSTL has broadened its appeal beyond institutional government customers to commercial enterprises.

In the past few years, the U.K.-based company has twice partnered with OHB AG of Germany to beat competing bids from Astrium Satellites to build Europe's Galileo navigation constellation, an indication that SSTL operates independently of its parent company.

Today, the company is working on a smallsat telecom platform that will operate in geostationary orbit, a nanosatellite constellation based on smartphone technology and a platform for small synthetic-aperture radar satellites that is partly financed by the U.K. Space Agency. Sweeting spoke with AW&ST *Paris Bureau Chief Amy Svitak in Guilford, England.*

Sir Martin Sweeting

Age: 61

Education: : Ph.D. in electronic engineering and communications from the University of Surrey.

Career: Pioneered the concept of rapid-response, low-cost, highly capable small satellites for science and engineering research utilizing off-the-shelf technology. In 1985 he formed Surrey Satellite Technology Ltd., which designed, built, launched and now operates 37 satellites in orbit. Today SSTL and its affiliates employ nearly 600 workers, and last year the company posted annual sales of more than $140 million.

AW&ST: SSTL is known for its work in the area of very small satellites, but the company is increasingly shifting to larger spacecraft and subsystem development. When did this shift begin?

Sweeting: We developed our first mini-satellite in the 1990s, which really formed the gear change from micro-satellites to mini-satellites. That allowed us to develop larger spacecraft for Earth observation and then navigation, and now we're building 22 payloads for Europe's Galileo satellite navigation constellation.

How have you increased production capacity as a result?

In addition to Galileo we had a number of other spacecraft, including an Earth-observation constellation for 1-meter imaging. All of that meant we had really outgrown our existing facilities, so two years ago we started construction of a new technical facility that provides us with much greater manufacturing capacity. It is now pretty heavily utilized for Galileo and six other satellites.

Your next big project in Earth observation involves building satellites that will be leased by a Chinese company through your subsidiary, DMC International Imaging (DMCII). How much capacity are the Chinese planning to lease?

We spun out DMCII six or seven years ago and it has grown to 20 people. As part of that we've received a lot of inquiries for additional data, and we proposed building a constellation of high-resolution Earth-observation satellites. In the meantime, 21-AT of China, already a partner in the DMC consortium, expressed interest. SSTL is building and will own these four new satellites, but the capacity of the first three has essentially been leased by our Chinese customer.

Will all four satellites be launched at the same time?

When we have a customer for the fourth, we will add it into the system. We plan to integrate and launch the first three together. As additional customers come online, we will launch further satellites.

SSTL established a U.S. subsidiary in Englewood, Colo., several years ago. Is the U.S. market for small satellite systems materializing as expected?

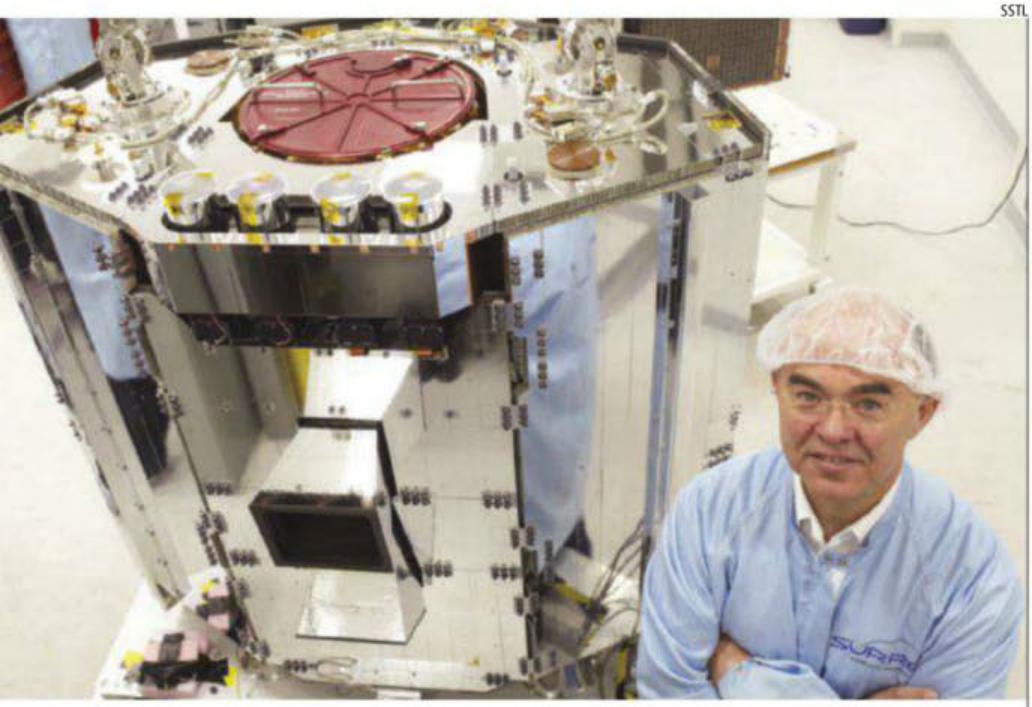
It's certainly been more difficult to break into the U.S. market, even when we are located in the U.S. It's quite complicated to find the right sort of partners, so we decided to keep growing organically. We're four to five years in and have about 10 people and a fairly modest revenue. On the positive side, we recently won the Cyclone Global Navigation Satellite System contract to provide payload subsystems and we're about to expand our capabilities in the U.S. partly because of that, but partly because in conjunction with our parent EADS we're going to have to expand our capabilities in order to make the business grow a bit faster.

What is your five-year plan for the U.S. operation?

The plan is to create an entity which essentially duplicates what we have here in the U.K. at SSTL, but one which is located and tuned into the U.S. market. It is difficult to do business in the U.S. from the U.K. The U.S. operation will need some support initially from SSTL in the U.K., but within five years we expect it to be a major supplier of small satellite systems and to be fully self-sufficient. In due course, we could have other locations on both the East and West coasts.

Has the defense market for small satellites emerged as expected?

It has certainly become more fashionable than anticipated. A certain number of initiatives have lurched off in different directions, and some of those directions haven't materialized. But there's clearly strong interest within the U.S. Defense Advanced Research Projects Agency, growing interest in the U.S. Army and Air Force, and there is realization of the role small satellites can play alongside larger assets. The institutional government markets are resistant to change because it just appears to increase risk. Until budgets really, really bite, the shift is gradual. But the U.S. Defense Department has been a bit more flexible and a little bit more imaginative in picking up what small satellites can do.


SSTL

How is the launch vehicle market shaking out for small satellites? Is it more difficult to find affordable, reliable options given the uncertainty in the Russian launcher market with regard to Dnepr?
That's definitely a concern. We keep in very close contact with our colleagues in Russia, Ukraine and elsewhere. The availability of Dnepr has been questionable for some time because a slightly different financial model is needed now that the Russian military has no launchers in their active armory. There is going to be a lot of negotiation as to additional costs, who should pay for [the launch vehicles] and how much, and whether the Dnepr remains commercially attractive. It is an extremely good vehicle. Plenty are left and it would be a shame not to use them.

What about other launch vehicles?
We can no longer use Russia's Cosmos, which was another very good vehicle and Rokot is essentially grounded for the time being. The new Soyuz is coming up and we're watching the evolution of Vega, although that's not a terribly cheap solution. We were disappointed when SpaceX withdrew Falcon 1, which was quite suitable for us. But they want to focus on the larger, more rewarding market and Falcon 1 was not going to yield the returns compared to Falcon 9.

You're helping Virgin Galactic design an interface to carry small satellites on WhiteKnightTwo. You must be optimistic about the venture.
It is technically quite feasible, it [all comes down to financing]. Further downstream there's the other U.K. initiative called Skylon and an air-breathing system the government is taking an interest in. But that is a decade or two away.

What is the status of your radar satellite line?
We started out with our optical cameras and over the years they have become better and better. So the next generation is going to be a 1-meter system on a small satellite. And we've always wanted to augment the optical with radar so you've got day-and-night and particularly all-weather imaging. But radar is traditionally very expensive and an order of magnitude more than optical satellites. So we've been working for about 15 years on how we could put a radar onto a small micro- or mini-satellite, but we've never quite managed to get it. When EADS took shares in SSTL we found they had that expertise, and that finally put the missing bits in. Within six months we had a demonstration payload that allowed us to submit a proposal for a radar mini-satellite which is essentially going to focus on deforestation, maritime surveillance and flood monitoring on a 300-400-kg (661-881-lb.) spacecraft. The U.K. has agreed to provide roughly half the funding. We're seeking a partner for the other half, and we'll be ready for launch also in 2014.

You launched a very sophisticated nanosatellite in the 1980s that attempted an in-orbit rendezvous with another small satellite using attitude control and autonomous GPS. Is a follow-on planned?
We've been working on making very small satellites and satellites on a chip, and have recently been looking at how to take advantage of the electronics that are essentially inside a smartphone, because much of that is what we need in a satellite. We're using that as the kernel for a really tiny, sophisticated satellite and we now have the next-generation ready for launch. It's called Strand (Surrey Training, Research and Nanosatellite Demonstrator) and with it we'll have the opportunity to build a number of these small satellites and to assemble them in orbit. Strand-1 is ready for launch at the end of this year, Strand-2 next year. We're holding discussions on the final agreements with the launch agency.

Do you see a growth trend toward smaller satellites in the Earth-observation market?
We look carefully at what customers want—and for what price—and construct the satellite around that rather than trying to provide the highest performance in all aspects, which drives up the costs non-linearly. Radar is an example. The applications we identified as critical to that market were monitoring forests, floods and maritime surveillance. Those three together are compatible. If we added interferometry and precise ice measurements, for example, the satellite would grow exponentially. Keeping the unit cost down allows us to launch constellations feasibly, providing the other dimensions of temporal resolution as well as spatial and spectral resolution.

What is your take on the recent demise of U.S. small-satellite manufacturer AeroAstro?
I've known AeroAstro for a long time. I do not know what happened. We looked at possibly teaming with them years ago. They had a couple of different acquisitions and I think they never quite managed to tune their approach to the market. It is a shame. They're a kindred spirit, but space is not an easy business.

VIRGIN GALACTIC CONCEPT

Virgin Galactic is proposing an air-dropped smallsat launcher.

Low-Cost Launch

Launch-service providers see a new market in growing acceptance of small satellites

Frank Morring, Jr. Washington

If all goes as planned, a United Launch Alliance Atlas V will lift off from Vandenberg AFB, Calif., later this week with a classified National Reconnaissance Office (NRO) payload on board. Already tucked into a special carrier suspended from a helium tank in the rocket's upper stage, right next to the RL-10 engine, are 11 tiny satellites riding to orbit as secondary payloads.

Some of the cubesats are flying NRO missions, but four were built at U.S. universities by engineering students and all of them were integrated into their spring-loaded deployers at California Polytechnic State University.

Cal Poly developed the Poly-PicoSatellite Orbital Deployer (P-POD) used by most cubesat builders these days. Essentially square tubes that eject as many as three 10 X 10 X 10-cm cubesats at once, P-PODS can be tucked into extra space on any launch vehicle's upper stage where they don't get in the way of the primary mission.

In the NRO launch, NASA's Office of Education arranged for the university cubesats to fly on the Atlas V Aft Bulkhead Carrier developed with funding from the NRO Office of Space Launch. The civilian space agency finds rides to orbit for student-built spacecraft under its Educational Launch of Nanosatellites (ELaNa) program, which sends the educational tools to space at essentially no cost to the schools that built them.

The ELaNA process illustrates a big advantage of small satellites—their low cost to orbit.

"Smaller satellites are not only generally cheaper to build, but they're also cheaper to launch," says John Roth, vice president for business development at Sierra Nevada Space Systems, which specializes in smallsats. "And since the launch cost is a large percentage of mission cost, if you can get your satellite as a secondary payload on a launch—or at least get it on a small launch vehicle rather than a large launch vehicle—you save tons of money. You save probably more than the cost of the satellite just in the launch cost."

A NASA-built cubesat is already in orbit on Japan's third H-II Transfer Vehicle (HTV-3) after its July 20 launch from the Tanegashima Space Center, but it will not be deployed until September or October. Developed at Ames Research Center, the Technical and Educational Satellite (TechEdSat) will be jettisoned into space from the exposed "porch" of the Kibo Japanese Exploration Module by a new version of the P-POD called the Small Satellite Orbital Deployer (J-SSOD).

The Japan Aerospace Exploration Agency developed three of the five cubesats to be lofted from the J-SSOD, but TechEdSat will be the first U.S. cubesat deployed from the Japanese exposed facility. A Vietnamese cubesat is also scheduled for a deployment arranged by Nanoracks, a U.S. company that hopes to provide more cubesat deployments from the ISS (*AW&ST* June 25, p. 44).

With increasing military interest in cubesats and small satellites in general, the U.S. Defense Advanced Research Projects Agency (Darpa) has awarded $46 million in 18-month Phase One contracts under its Airborne Launch Assist Space Access (Alasa) program to Boeing, Lockheed Martin and Virgin Galactic. The goal is to launch payloads weighing less than 100 lb. to low Earth orbit on 24-hr. notice for no more than $1 million (*AW&ST* June 25, p. 33).

Announced at the Farnborough air show, the unmanned LauncherOne smallsat vehicle (see photo) will use the same WhiteKnightTwo carrier aircraft that Virgin Galactic plans for its SpaceShipTwo human suborbital missions (*AW&ST* July 9, p. 119).

Virgin says its plans call for first flight of the smallsat launcher in 2015 and commercial flights beginning by 2016. With suborbital passenger flights on SpaceShipTwo possible by the end of 2013, the smalsat launches would be another revenue source for the startup.

Even without the million-dollar launches envisioned by Darpa, there is already a wide variety of small, relatively low-cost vehicles available for smallsats, including the Russian Dnepr, Rokot and Kosmos 3M; the U.S. Pegasus and Minotaur; India's Polar Satellite Launch Vehicle; and eventually, perhaps, launchers under development in Argentina, Brazil, South Korea and even China.

SPACE

A Birthday Celebration

Michael Mecham

On July 23, NASA and the U.S. Geological Survey (USGS) celebrated the 40th birthday of Landsat, the Earth-observing satellite series most closely identified with building a continuing data stream about how population growth, climate change, natural events and man's activities are influencing the planet.

With the celebration comes word of how a new facility that taps the Pleiades supercomputer at NASA Ames Research Center is helping to expand the Landsat story. Called the NASA Earth Exchange (NEX), the facility "brings scientists virtually into the [Landsat] system," says Ames Senior Earth Scientist Rama Hemani. In the past, users have tapped Landsat image data by downloading it from the USGS's Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, S.D., and processing it on their own. Over the years, the EROS library has grown to 9,000 scenes, or tiles. All were taken from the same 400-mi.-high orbit and cover the planet in 165 X 165 km (102 x 102 mi.) swaths at 30-meter (98-ft.) resolution. Whether heritage views or the latest recordings, the data are so rich that without NEX, processing large chunks of it can take 10-15 days, Hemani says. NEX zips it by in less than an hour.

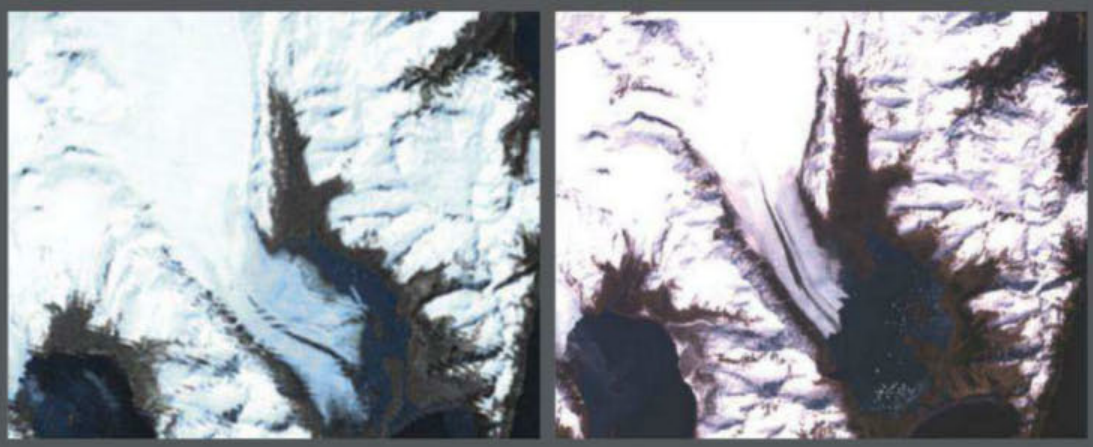
Lockheed Martin Space Systems has built all seven Landsats. Two are currently operating. After 27 years on the job, Landsat 5's Thematic Mapper conked out last year, but its multispectral scanner is still going strong. Thirteen-year-old Landsat 7 is the youngster.

Urban planning leads the list for data requests, but global warming, deforestation and disaster studies are also big draws. When the Landsat era began, computing time was too expensive for most researchers. As processing costs were dropping, the price for images was rising. At $5,000 each they proved too rich for most, but two years ago Landsat data became free. Demand has exploded, Hemani says.

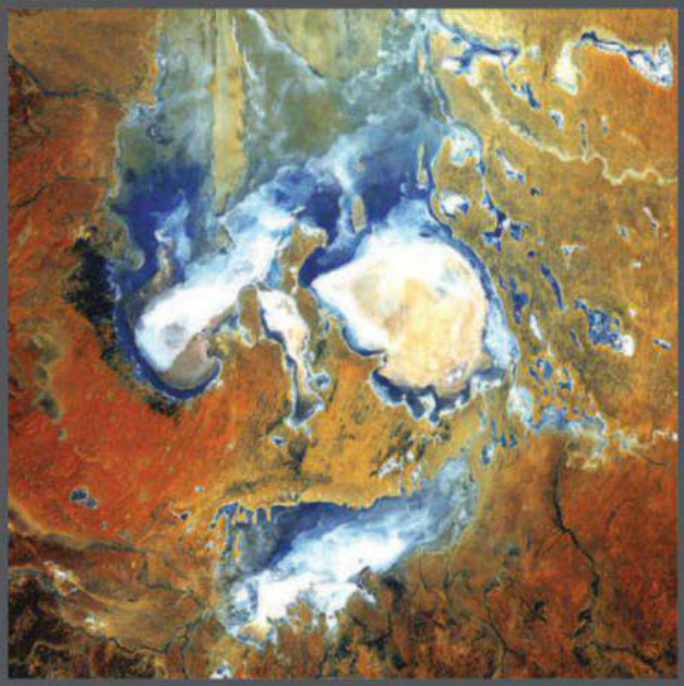
Success begets success. The world's Earth-observing fleet now includes science satellites that measure the upper atmosphere molecule by molecule and commercial satellites with pinpoint resolution so fine that consumers buy pictures of their homes taken from space. The next satellite in the series is due for launch in February. Called the Landsat Data Continuity Mission, it is being built by Orbital Sciences Corp.

ALL PHOTOS NASA GODDARD/U.S. GEOLOGICAL SURVEY

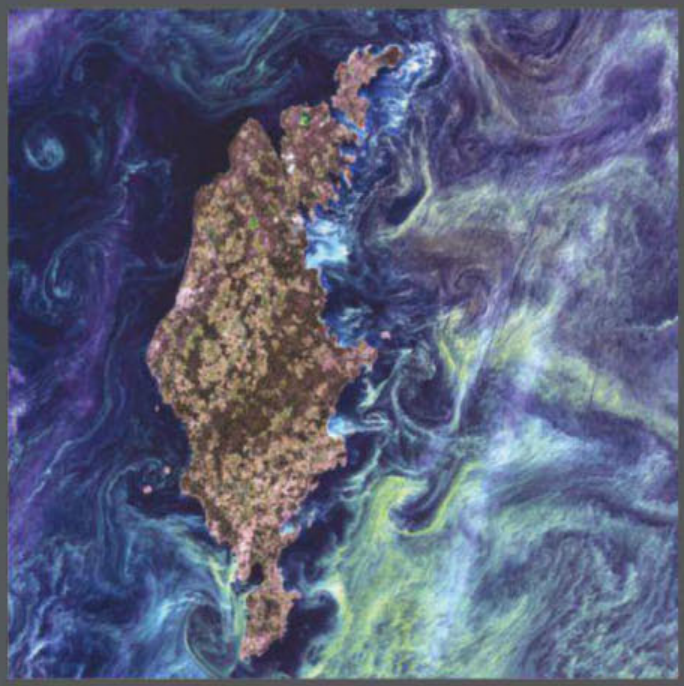
The great strength of Landsat's 40-year-old data sets is demonstrated in these color infrared images of urban growth in greater Washington. Red indicates grassy fields and forests; light blue shows urban development. Above is a Sept. 23, 1972, image from Landsat 1; below is a May 28, 2012, image from Landsat 7.



A comparison of a Landsat 3 image of Bear Glacier in south central Alaska from June 1980 (far left) to a Landsat 7 image taken in May 2012 shows how warming in the region has reduced the buildup of snow, providing less material for the glacier's growth.



Inundated patches in shallow Lake Eyre turn this view of the desert in northern South Australia into a face-like image. Although Australia's largest lake, Eyre has been filled completely only three times in the past 150 years.



In August 2005, Landsat 7 imaged this greenish swirl in the dark waters off Gotland, a Swedish island in the Baltic Sea. The swirl represent a "bloom" of phytoplankton that arises as deep currents bring nutrients to sunlit surface waters.

ALL PHOTOS NASA GODDARD/U.S. GEOLOGICAL SURVEY

An urban land-use study of Memphis, Tenn., turns into a work of art as Landsat 7 captured the swirls of the Mississippi River in 2003.

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Future Events

Sept. 19-21—MRO IT Conference & Showcase. Miami.
Oct. 9—MRO IT Europe. Amsterdam.
Oct. 9—Aircraft Composite Repair Management. Amsterdam.
Oct. 9-11—MRO Europe. Amsterdam.
Oct. 30-31—Engine MRO Europe. Paris
Nov. 6-7—A&D Programs. Phoenix.
Nov. 13—Engine MRO Asia. Singapore.
Nov. 14-15—MRO Asia. Singapore.
Jan. 22-23—MRO Middle East. Dubai, United Arab Emirates.

Aerospace Calendar

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Aug. 7-10—Association of Unmanned Systems North America 2012 Exhibition. Mandalay Bay Hotel. Las Vegas. See www.auvsishow.org/auvsi2012
Aug. 13-14—Bombardier 2012 Safety Standdown Latin America. Grand Hyatt Sao Paulo Hotel. See www.safetystanddown.com
Aug. 13-16—American Institute Aeronautical and Astronautics/American Astronautical Society's Astrodynamics Specialist Conference. Hyatt Regency Minneapolis. See www.aiaa.org
Aug. 15-17—Ninth Annual Latin American Business Association Conference & Exhibition. Congonhas Airport, Sao Paulo. See ww.abag.org.br/labace2012/
Aug. 27-31—International Society of Air Safety Investigators' 2012 Annual Seminar. Baltimore Marriott Waterfront Hotel. See www.isasi.org/isasi2012.html
Aug. 28-30—2012 Aircraft Owners and Pilots Association's Shanghai International General Aviation Show. Shanghai World Expo Exhibition and Convention Center. See www.sh-aero.com/en/
Sept. 4-5—Association of Aerospace Industries' Human Factors and Error Management Short Course. Nah Wah Building, Singapore. See www.aais.org.sg/human_factors
Sept. 4-7—Netherlands Association of Aeronautical Engineers' 38th Annual European Rotorcraft Forum. Amsterdam Marriott. See http:erf2012.nlr.nl
Sept 6-9—56th Annual Tailhook Reunion USMC Aviation Centennial. Nugget Hotel, Reno, Nev. See www.tailhook.org

PARTNERSHIPS

Aug. 6-9—Association for Unmanned Vehicle Systems International. Las Vegas.
Oct. 1-5—63rd International Astronautical Congress. Naples, Italy.
Oct. 9-14—Japan Aerospace. Nagoya.
Nov. 13-18—Airshow China. Zhuhai.
Dec. 11-13—Middle East Business Aviation. Dubai, United Arab Emirates.

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Be Affordable And Agile. Or Die.

BY JOHN DOWDY

Dowdy leads McKinsey & Co.'s global aerospace and defense practice.

With commercial aerospace booming and defense markets cooling, business leaders in the sector are searching for a recipe to guide their actions in these uncertain times. Given the cyclical nature of aerospace and defense markets, it would be natural to look to the past for clues as to which strategies have worked in similar times. But this time is different. To succeed in this environment, companies will have to master new skills, become more agile and develop more affordable products than at any time in the past.

Both commercial aerospace and defense are inherently cyclical markets. Growth in the commercial aerospace market tracks global economic growth, with a short lag, historically following a 10-11-year cycle. We currently find ourselves in Year 13 of a commercial aerospace boom, the longest in recent memory. Some analysts are claiming there will be no protracted down cycle this time, as Middle Eastern and Asian airlines pick up the slack from those in traditional developed markets. Other analysts, however, are much less optimistic, saying you only recognize a bubble once it has popped.

> "The last time we saw commercial aerospace booming and defense struggling was at the end of the Cold War. But today, the underlying drivers are sharply different."

Spending on commercial aerospace and defense tends not to be connected, which is why many A&D companies like to have both in their portfolio. Defense is also cyclical, but is driven by threat levels (actual and perceived) rather than economic cycles. The last two cycles for defense spending both lasted around 20 years. We now find ourselves in the early stages of a downturn in global defense spending.

Surely, we have been here before: Commercial aerospace booming, defense trending downward. What can we learn from historical patterns? The last time we saw commercial aerospace booming and defense struggling was at the end of the Cold War. But that is not relevant because the underlying drivers of activity then and now are surprisingly different.

Affecting commercial aerospace today, airline profits are down, oil prices are high, and global economic growth is anemic. Curiously, these are factors normally more associated with a commercial aircraft down cycle. And in today's defense environment, the threat has not dissipated, as it had at the ends of the Korean War, Vietnam War and Cold War. There is no obvious peace; we still find ourselves in an uncertain and dangerous world.

With the fundamentals so out of alignment with market conditions, we are living in an unstable equilibrium. What's an A&D executive to do?

In commercial aerospace, everyone is talking about the problem of overstretched supply chains, but with all of this uncertainty, the real challenge for commercial players is to improve their agility, to enhance their ability to respond flexibly to changes in the market. Companies that have succeeded in doing this in other sectors have typically shortened their lead times substantially in order to be more responsive to shifts in the market. For example, personal computer lead times have been compressed from 14-21 days in 1990, to only two days in 2010.

In defense, companies are already looking for new pockets of growth, in segments like UAVs and cybersecurity and in international markets. But everyone is chasing the same set of opportunities. So competitive intensity is high. Since not everyone will be able to build successful businesses in these areas, some companies are beginning to rationalize their portfolios. In the good years, the rising tide lifted all boats and everyone benefitted. Good companies did well. Average companies did well. Even poor performers were able to reap the fruits of a strong market. In a flat or down market, only strong companies perform well. As a result, now is the time to exit segments and individual businesses that are underperforming.

The real management challenge is to push for affordability. In the world we have been living in, a slightly better product at a higher price was almost always a winner. In the new, more austere world, a good-enough product at a lower price is increasingly attractive.

We have seen several examples of this in the market. For example, a greater emphasis on price was more prominent in India's recent Medium Multi-Role Combat Aircraft competition. Similarly, Oshkosh Corp.'s success in the recent medium tactical vehicle replacement competition saw a company which styles itself as a manufacturer of severe-duty trucks (with a cost structure to match) prevail over more established defense players.

Agility and affordability—not necessarily hallmarks of the aerospace and defense today—are likely to become the hallmarks of success in the future.

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