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The strategy of U.S. defense contractors to increase international sales to offset a tightening military budget at home is starting to show results. One example is a potential \$1.1 billion deal by Sikorsky to sell UH-60 helicopters to Qatar.



- 28 **Combination of** automation, process improvements and a push on hiring will make 777 production possible
- 29 **Target for certification** of Comac's 90-seat RJ has been delayed again, to 2014, for a 12-year development
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- 38 **Expansion of** anti-submarine warfare mission puts Malaysian navy in line for new helicopters

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46 Workers prepare HA-420 HondaJets at Honda Aircraft's 500,000-sq.-ft. manufacturing and R&D facility in Greensboro, N.C. The four-passenger light jet and its GE Honda HF120 engines are undergoing certification testing, part of the trend by foreign business jet manufacturers to produce in the U.S. Honda Aircraft photo.



32 Top official of French aerospace association says the country's equipment manufacturing industry is entering a new phase.

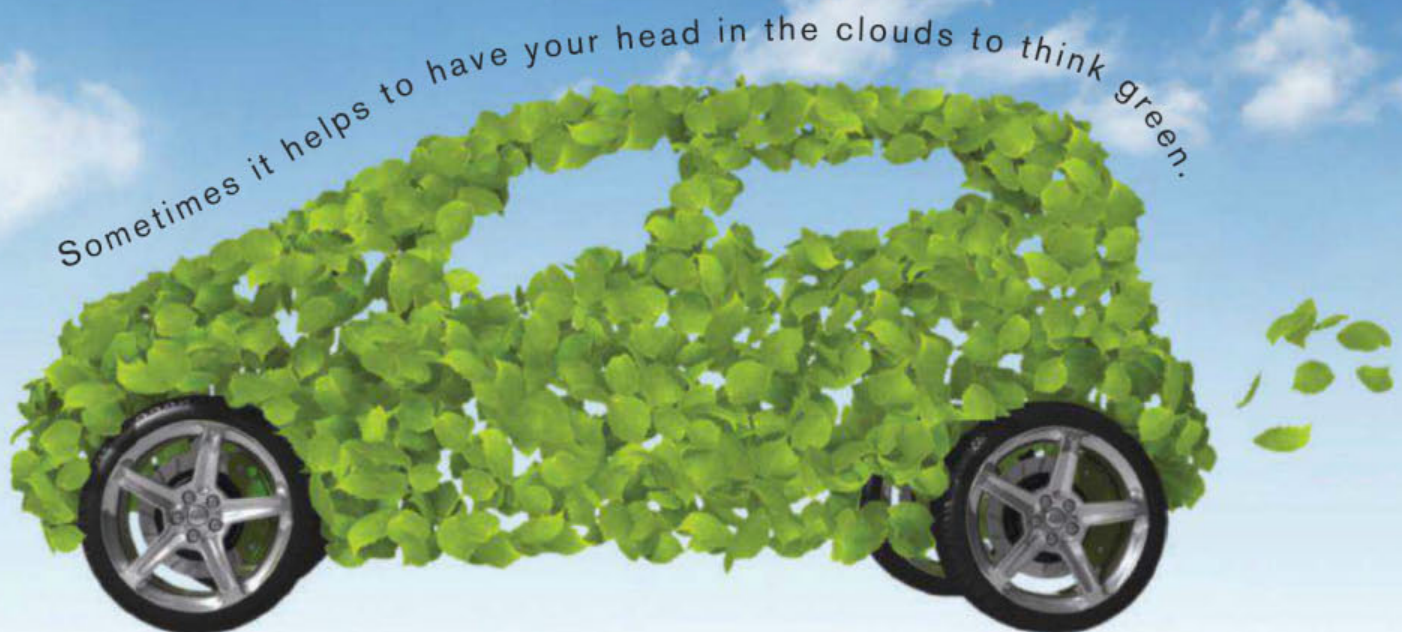


29 Comac's target for certification of the ARJ21 has been delayed again, to 2014 from the previously scheduled mid-2013.



Widely regarded as the world's premier aerospace university, Embry-Riddle actually applies much of its expertise to address some of the most perplexing problems on spaceship earth. For example, a team of faculty and student researchers is competing in the EcoCAR 2 Challenge, a competition sponsored by General Motors and the U.S. Department of Energy. The team's design features a bio-diesel engine, a 25-mile all-electric range, and an advanced adaptive control system. Yes, at Embry-Riddle we aim for the stars. But we always keep home close to our hearts.

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LOCKHEED MARTIN



NOT SO BUOYANT

💬 **The U.S. Government Accountability Office's** Oct. 23 report on Pentagon aerostat and airship programs was not encouraging. Senior Technology Editor Graham Warwick analyzes the report on our Ares blog and estimates the likelihood of any of these programs flying. Read the whole post at: tinyurl.com/9tfef9u
AviationWeek.com/ares

NBAA SPECIAL

✨ **Stay up to date** on developments from the National Business Aviation Association's annual meeting and convention. Our team in Orlando, Fla., will provide news, blog posts, photos and more, keeping you abreast with what's going on at the show.

AviationWeek.com/nbaa

DESERT TO SKY

💬 **Two space access projects** are making significant progress at

Mojave Air and Space Port in California: Stratolaunch Systems, Paul Allen's project; and Virgin Galactic's SpaceShipTwo, at Scaled Composites. At some 1.2 million lb., Stratolaunch's twin-boom vehicle will be the largest aircraft ever built. Read

more on our On Space blog: tinyurl.com/9ye3aa6

DOES PERFORMANCE COUNT?

💬 **What is the benefit** of being a publicly traded company? That's the question analysts were asking of Hawaiian Airlines, which has seen its share price stagnate even as its operational and financial metrics soar. Read the analysis on our Things With Wings blog: tinyurl.com/cufkvnz

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From the Web

Comments from readers
on AviationWeek.com



Congressional Editor Jen DiMascio examines Mitt Romney's off-again, on-again position on the F-22 Raptor, noting it's not the first time during the presidential race that a defense message has been reversed. In July, President Barack Obama contradicted his own fiscal 2013 budget request regarding base closings. See "Up In The Air" on the Ares defense blog, and add to the discussion.

Talos 4 says:

It's an illusion to assume they [Romney and campaign booster Dov Zakheim] even know the difference between an F-22 and an F-35.

RSF opines:

Considering how much "detail" we've received from the Romney camp to date, I'm not sure they even understand the differences between the aircraft types. I keep hoping someone will restart F-22 production and create an exportable Raptor, but at this point I agree with another blogger: "The Raptor is deadlier than Elvis! Long live the king..."

Space Editor Sean Meade has posted on the On Space blog photos and a video of Xcor Aerospace's full-scale model of its two-seat Lynx suborbital spaceplane—which it intends to debut at the International Symposium for Personal and Commercial Spaceflight.

DeweyW notes:

It looks like the pilot drives it with stick, not a yoke, and reads round analog gauges. With no head-up display and only two glass screens, maybe space tech isn't progressing as fast as we thought.



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

Feedback

BREAKTHROUGHS WORTH THE COST

A recent Washington Outlook item (AW&ST Oct. 15, p. 25) quotes father-and-son duo Dov and Roger Zakheim saying: "A Mitt Romney administration would [among other things] avoid the difficulties that stymied early attempts at acquisition reform by... building new weapons incrementally from existing platforms and technologies." Had previous administrations followed this approach, we would not have had, among other systems, the B-47, B-52 and B-2 bombers; the P-80, F-4, F-16, and F-22 fighters; the Chinook family of helicopters; laser-guided bombs; GPS; Aegis air defense radars on ships; and a host of other systems that make the U.S. armed forces the leaders without peer in the defense world. These systems and weapons, and others, broke new ground technologically.

The cost was usually more than had initially been estimated, but this came about because our defense procurement system—especially Congress, which must authorize the procurements and appropriate the money—does not provide for the length of a system development, nor does it allow for contingency funding to account for the "unknown unknowns" involved with technological breakthroughs.

This induces the military and the A&D industry to make promises that can't be kept and keeps them in the position of being supplicants for rescue.

The Zakheim (and Romney?) prescription for weapon system acquisition would lead to stagnation and decline in the strength and power of our armed forces. And if a putative President Romney could persuade Congress to change its approach to defense authorization/appropriation, it must also be noted that such an attempt would be far from the first to fail. Congress guards its prerogatives strongly.

S.J. Deitchman

CHEVY CHASE, MD.

IN DEFENSE OF FALCON 9

Reader Dale Jensen incorrectly portrays rocket launches as being detrimental to the environment (AW&ST Oct. 1, p. 10). First, weekly space or missile test launches would have to be increased by many orders of magnitude to even earn a "trivial contributor" title. Second, all liquid-fuel engines actually burn very cleanly compared with most other of our industrial and transportation processes. All fuel is fully burned

Aviation Week & Space Technology welcomes the opinions of its readers on issues raised in the magazine. Address letters to the Executive Editor, Aviation Week & Space Technology, 1200 G St., Suite 922, Washington, D.C. 20005. Fax to (202) 383-2346 or send via e-mail to: awstletters@aviationweek.com

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either in or beyond the engine, leaving no visible trail other than vapor.

Also, Jensen's math is faulty. Mixtures are chosen to provide the highest performance, not just to make a "cheap" engine. These ratios are sometimes fuel rich to provide the highest impulse. For hydrogen engines, the ideal ratio is 5.5-6:1. For hydrocarbon engines, the ideal ratio is about 2.56:1 (also by weight). The Falcon system uses this ratio.

The maximum practical specific impulse (ISP) for a hydrocarbon engine is about 338 sec., which is attained in some Russian engines via staged combustion. The Falcon engine uses a gas generator system for a fair trade-off in terms of cost/performance. The ISP is 305 in a vacuum as a result.

Al Knutson

BURNABY, BRITISH COLUMBIA

EARLY 'ATE' ADVANCES

In "Green Machine" (AW&ST Oct. 8, p. 40), it seems Boeing is late to the adaptive trailing edges (ATE) party, as is Airbus. ATEs were introduced in the early 1970s by German high-performance glider manufacturers Alexander Schleicher and Schempp-Hirth.

Negative flap setting allowed the pilot—at high penetration speeds—to lose less altitude because negative settings raised the nose of the airplane, thus also losing less altitude.

Henning Otto

SANDPOINT, IDAHO

UNENFORCEABLE BANS

In "UAV Accountability," reader Terry Welander advocates the untenable position of banning UAVs from the national air space because of a postulated hazard (AW&ST Oct. 15, p. 10).

A ban would do nothing to prevent criminal/terrorist attacks because those people do not pay attention to such strictures. Prevention comes only through the application of proactive measures that provide real, physical countermeasures to defeat threats.

Thomas L. Parker

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Dale Keller

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James Culmo (see photos) has been appointed VP of *Northrop Grumman Corp.*'s newly formed High-Altitude, Long-Endurance Enterprise, based in Redondo Beach, Calif. He has been VP and deputy general manager for the Military Aircraft Systems business. **Kathryn G. Simpson** has been named VP and deputy general counsel. She was VP-legal, corporate transactions and governance at the Raytheon Co. **James W. Stephenson** on Dec. 1 will become VP, associate general counsel and sector counsel for the Electronic Systems Sector, succeeding **Dennis Cameron**, who plans to retire. Stephenson has been assistant general counsel for the Information Systems sector.

J. Randolph "Randy" Babbitt has become senior VP-labor relations for *Southwest Airlines*. He was FAA's administrator through December 2011 and has been president and CEO of the Air Line Pilots Association.

Rob Bishton has been named operations director of London Gatwick Airport-based *FastJet*. He was head of flight operations at *EasyJet*. **Kyle Haywood**, former CEO of Air Uganda, is the new general manager for Africa, and **Harun Cordan** has been named chief pilot and head of flight operations. He was a chief instructor at Ryanair.

USN Vice Adm. (ret.) **John Morgan** has been named chairman and CEO of Washington-based *Nobles Worldwide*. Morgan commanded the USS Enterprise carrier battle group, among his assignments during a 30-year naval career.

Michael Iuro has joined Schaumburg, Ill.-based *Dekra's* Safety Consulting Engineers Div. as business operations manager. He was VP of architecture and property development company Iuro & Associates Corp.

Guy Snelgar (see photo) has been promoted to managing director from business development manager of Southlake, Texas-based *GetThere's* business in Europe, the Middle East and Africa.

Dennis K. Diemoz has been named president of Douglas, Isle of Man-based *Excalibur Almaz's* U.S. operation. He was VP and general counsel of the United Space Alliance

and has been company counsel at Lockheed Martin Space Operations.

Douglas Hofsass has been appointed assistant administrator for the Office of Risk Based Security of the U.S. Transportation Security Administration in Washington. He was associate administrator.

Scott Kaine has become president of McLean, Va.-based *Qinetiq North America's* Cyveillance subsidiary. He was senior VP of CA Inc.

Marc Gordien and **Ralph Anker** have joined Manchester, England-based *ASM* (Airport Strategy and Marketing) as VP-consultants. Gordien was project director at Sabre Airline Solutions, and Anker was part of the network planning teams of Go Fly Air, Maersk Air and EasyJet.

Jack Arehart (see photo) has been named co-chief commercial officer of Wood Dale, Ill.-based *AAR Corp.* He was VP-commercial sales and marketing.

Liam Quinn has been appointed business development manager at Johannesburg-based *South African Airways*. Also joining the airline are: **Jon Danks**, head of U.K. marketing and communications; **Stephen Gerrard**, commercial manager; **Matt Parr**, leisure sales manager; **Philip Ariss**, corporate sales manager; and **Kerry Farmer**, online sales manager.

Remi Volpe (see photo) has joined Minneapolis-based *Honeywell Sensing and Control* as VP-general manager for the Europe, Middle East and Africa regions. He was the area's marketing director for buildings and CentraLine business leader for Honeywell's Environmental & Combustion Controls business.

Chris McDowell has become VP-sales and marketing at Richmond, British Columbia-based *Vector Aerospace Helicopter Services*. He was VP-sales and business development at Heli-One.

Charles P. Zimkas has been promoted to president from chief operating officer at the Colorado Springs-based *Space Foundation*.

Dale Keller (see photo) has been named CEO of the London-based *Board of Airline Representatives*. He has held management roles with Air Mauritius and Air Malta, and was a BAR U.K. board member.

HONORS AND ELECTIONS

Brandon Fried, executive director of the Washington-based Airforwarders Association, has been named to the U.S. Commerce Department's Advisory Committee on Supply Chain Competitiveness.

Emilio Romano, president of Telemundo Media and former CEO of Mexicana, has been named to the independent panel of judges for the Federico Bloch Award, presented by the *Latin American and Caribbean Air Transport Association*.

Mark Rathert, general manager for ground operations for SES, is one of four new members appointed to the board of the New York-based *World Teleport Association*. The others are: **Francis Rolland**, CEO of GlobeCast U.K.; **Kurt Riegelman**, senior VP-global sales of Intelsat; and **Jose Sanchez Ruiz**, director of service operations at Eutelsat.

John L. Petersen has been elected chairman of the Anoka, Minn.-based *Charles A. and Anne Morrow Lindbergh Foundation*, succeeding **Larry E. Williams**, who has completed his three-year term. Petersen is founder and CEO of The Arlington Institute. ☼



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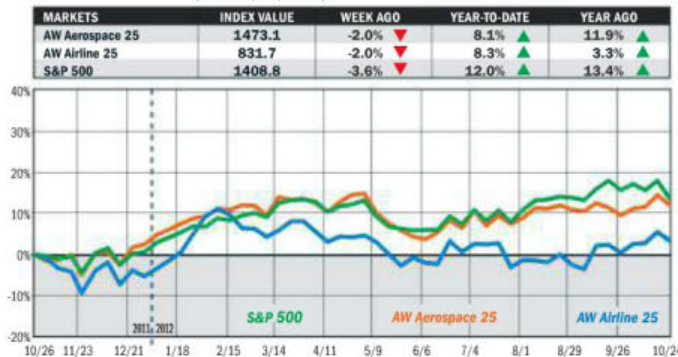
By Michael Mecham

Northern California
Bureau Chief Michael Mecham
blogs at: AviationWeek.com
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AW&ST/S&P Market Indices

(as of 10/24/2012)

PERCENT CHANGE



Weekly Market Performance

Closing Prices as of Oct. 24, 2012

Company Name	Current Week	Previous Week	Fwd. P/E	Tot. Ret. % 3 Yr.	Tot. Ret. % 1 Yr.
AIR TRANSPORT					
AAR Corp.	15.18	16.50	9.0	-26.9	-18.6 ▼
ACE Aviation Holdings	3.68	3.42	-2.9	168.2	42.6 ▲
AerCap Holdings N.V.	12.54	12.88	5.9	44.8	10.0 ▲
Air Berlin	2.01	2.06	-1.5	-58.1	-41.4 ▼
Air Canada	1.90	1.55	9.4	37.2	40.3 ▲
Air France - KLM	7.64	7.80	-4.2	-47.8	5.7 ▲
Alaska Air Group	38.35	37.77	7.3	184.2	16.4 ▲
All Nippon Airways Co Ltd.	1.98	2.02	12.4	-34.9	-32.4 ▼
Allegiant Travel Co.	68.64	68.91	13.3	90.0	32.4 ▲
Asiana Airlines Inc.	6.07	6.28	6.3	71.4	-18.7 ▼
Atlas Air Worldwide Holdings	52.66	53.47	9.5	48.5	39.8 ▲
BBA Aviation plc	3.34	3.42	11.5	47.7	19.3 ▲
B/E Aerospace Inc.	45.11	44.40	14.0	124.8	24.4 ▲
CAE Inc.	10.48	10.85	12.9	19.6	-0.9 ▼
Cathay Pacific Airways	1.77	1.76	22.0	20.7	1.0 ▲
China Southern Airlines	23.99	24.44		67.7	-9.2 ▼
Copa Holdings SA	88.69	87.75	11.0	127.4	31.7 ▲
Delta Air Lines Inc.	10.04	10.19	4.1	21.8	19.0 ▲
Deutsche Lufthansa AG	13.82	14.38	16.4	-1.8	8.1 ▲
EasyJet plc	9.74	9.72	10.0	63.8	72.8 ▲
FedEx Corp.	90.83	92.95	13.6	19.9	13.2 ▲
GOL SA	5.11	5.34		-51.5	-32.3 ▼
Hawaiian Holdings Inc.	5.74	5.43	4.0	-29.7	8.7 ▲
Heico Corp.	38.09	38.60	21.7	81.5	-11.6 ▼
Jet Airways (India) Ltd.	6.62	7.05	-8.8	-17.7	51.8 ▲
JetBlue Airways	5.20	5.26	10.0	-3.3	19.3 ▲
Korean Air Lines Co. Ltd.	45.30	44.99	8.7	5.8	0.4 ▲
Lan Airlines SA	24.70	26.10	23.0	86.6	7.3 ▲
Qantas Airways Ltd.	1.37	1.38	11.7	-54.1	-10.6 ▼
Republic Airways Holdings Inc.	4.78	5.06	4.9	-47.5	83.1 ▲
Ryanair Holdings ADS	32.73	33.25	75.9	20.6	19.1 ▲
Singapore Airlines Ltd.	8.71	8.72	23.8	-13.9	-3.6 ▼
Skywest Inc.	11.24	11.45	9.2	-22.3	-10.0 ▼
Spirit Airlines Inc.	17.18	17.80			14.3 ▲
Southwest Airlines	8.75	8.95	11.3	-0.4	0.7 ▲
TransDigm Group Inc.	131.42	149.00	17.9	248.9	57.5 ▲
United Continental Holdings Inc.	20.27	20.62	6.6	195.5	1.3 ▲
United Parcel Service Inc.	73.12	73.29	14.6	43.4	8.6 ▲
US Airways Group	12.37	11.62	4.5	235.2	120.9 ▲
WestJet Airlines Ltd.	17.48	18.35	10.0	58.2	35.8 ▲
Zodiac Aerospace SA	96.69	101.87	12.4	225.3	33.6 ▲

COMMENTARY

With 777X, Boeing Looks to Partnering

The operating efficiencies that the Boeing 787 gains from carbon fiber-reinforced polymers (CFRP) has made those materials—composites—the baseline for the product development team working on the 777X, despite a push by aluminum manufacturers that their lightweight alternatives are more aligned with Boeing's traditional manufacturing methods.

Boeing Chairman and CEO James McNerney certainly shined the spotlight on CFRP last week as he discussed a "suite of technologies that we can harvest" for the 777X and 787-10. "The kind of performance improvements that can be generated by the composite wing and new engines are pretty eye-watering," he said.

In an upbeat third-quarter financial report—Boeing's \$307 billion commercial airplane backlog has grown by 929 net orders this year and is now 4,100 aircraft—McNerney said the "bleeding" the company went through during 787 and 747-8 development gives it "a huge opportunity over the next decade or two" as it tackles new programs. "Building a composite wing of this size, an airfoil of this size"—the 777X's is baselined at 233 ft., 10 in., or 21 ft. longer than a 777-300ER's—"would not have been thinkable a decade ago. We now know how to do that and I can't think of anyone else who does."

Neither the 777X nor the 787-10 has been launched, but that seems only a matter of time. The -10 will make the 787 more attractive for international regional operations and the 777X will answer the challenge posed by the Airbus A350 family, particularly in the near-400-seat range.

Aside from formalizing whether the 777X will be built, Boeing has yet to answer where it will be made. Its 777 production line in Everett, Wash., is a model of improving productivity, but it makes aluminum wings and fuselages. Does Everett have room for composite wing manufacturing, which require completely different tooling? Or is the obvious choice to stick with the Japanese, especially **Mitsubishi Heavy Industries**, Boeing's preferred composite wing partner?

Despite the "bleeding" that went on with management of the 787's extended supply chain, the company shows no signs of backing away from the model. Productivity "needs to be refreshed and built upon all the time, because the world is going to get more difficult," McNerney says. "Partnering for success" in the supply chain is "an all-fronts kind of approach" to improve operating margins and offset inflationary pricing pressures, he says.

Partnering allows Boeing to control its own destiny "without stealing margin from our suppliers," McNerney adds. "It's not a zero-sum game. I've led enough Six Sigma efforts over my life to know that there's a lot of money in shared processes and . . . analytical approaches if people start with . . . some right-to-left thinking that we got to get things done." Discussions with partner CEOs are underway that will lead to multiyear change throughout Boeing. Look for them to show up in 2013. ☺

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.

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The World

DEFENSE

Amraam Away

The F-35 weapons-drop test program has advanced with another first. A Lockheed Martin F-35A jettisoned its first Raytheon AIM-120 Advanced Medium-Range-Air-to-Air Missile (Amraam) on Oct. 19. An F-35A previously dropped a 2,000-lb. Joint Direct Attack Munition while an F-35B dumped a 1,000-lb. version. The Amraam jettison is different, requiring the door-mounted rack to eject the missile.

Apache E

The U.S. Army has officially designated the AH-64D Block III attack helicopter the AH-64E and is preparing a contract with Boeing for full-rate production, according to Col. Jeff Hager, Army Apache project manager. The Army anticipates that Boeing will build seven per month—four for the service plus three for foreign customers such as Taiwan, Indonesia, Qatar and India. The Army plans to buy a total of 690.

Double Duty

Lockheed Martin is self-funding work to generate software that will allow for the AN/TPQ-53 radars being fielded to detect air-breathing threats as well as those in a ballistic trajectory, according to Lee Flake, director of counter-fire radar programs. These X-band radars are designed to provide 360-deg. detection of rockets and mortars. The U.S. Army has 65 under contract. The new software will provide data on the whereabouts of airborne threats, such as unmanned aircraft and cruise missiles.

Israelis Eye Tactical Radars

Israel's Elta is presenting new tactical radar options for the Israel Defense Forces (IDF), to meet a need for ultra-rapid response to mortar attacks. Although the IDF is quite capable at detecting outgoing rockets with highly sensitive sensor systems, crude and inaccurate enemy mortars still have terrorized the Israeli population in settlements along the Gaza Strip border. Unable to pinpoint these sources in time to prevent the firing of these smaller munitions, the short-range mortars remained a constant scourge, and the IDF has had countermeasures available to suppress this danger in an increasingly short sensor-to-shooting cycle.

AIR TRANSPORT

Encouraging Speea Talks

After weeks of dissidence, Boeing and the Society of Professional Engineering Employees in Aerospace reported progress on Oct. 24 in their four-year contract talks. "Today's negotiations were marked by a new spirit of collaborative problem solving," said Speea. Union President Tom McCarty said he was "pleased to hear that the Boeing pension is so well-funded the company does not need to make any contributions in the next year," after the company's third-quarter earnings report. But Robert Stallard of RBC Capital Markets said Boeing could face another \$1 billion in pension expenses next year. During last week's talks, Boeing presented an amended health care plan and Speea offered an amended retirement plan. Health and retirement benefits are ma-

jor sticking points for the contract. The current agreement has formally expired but remains in effect until Nov. 25.

Collins in C919 Pact

Rockwell Collins and China Electronics Technology Avionics Co. have agreed to establish Avic Leihua Rockwell Collins Avionics Co. to develop and manufacture communications and navigation systems for Comac's C919 regional jet.

Sharklet Testing Begins

The first Airbus A321 with sharklets (winglets) took off on its maiden flight from Hamburg last week. The aircraft flew to Toulouse and will start its flight-test program. Certification is planned for the middle of next year, and deliveries are expected to begin in the third quarter. The A321 is the second in the A320 family to be equipped with sharklets.

AEROSPACE BUSINESS

Spirit Struggles

Spirit AeroSystems Holdings warned of a \$590 million forward loss from Boeing, Rolls-Royce and Gulfstream fuselage, nacelle and wing programs as it prepared to report third-quarter earnings. The company said supply-chain savings it anticipated have not been achieved, resulting in a model that is not matching the actual costs of hardware being shipped. After adjusting its cost estimates, the company expects savings going forward. Spirit broke down the charges as \$184 million for the Boeing 787 program, on which it supplies the nose sections and wing leading edges; \$163 million for the Gulfstream G650 wing program; and

Blue Origin Tests Pusher Escape for Suborbital Capsule

Blue Origin will use test results with its suborbital New Shepherd crew vehicle of the pusher-type launch-abort system it developed with NASA funding to "inform" the design of its planned orbital space vehicle.

The Oct. 19 test at the company range near Van Horn, Texas, used a commercially procured solid-fuel rocket to boost a full-up New Shepherd to an altitude of 2,307 ft., with thrust vector control during powered flight, separate attitude control during coast and a parachute recovery 1,630 ft. away from the starting point.

"This is the first flight of our crew capsule system, and it's an integrated test, end-to-end for control, powered flight, attitude con-

trol, deceleration and landing," says Brett Alexander, director of business development and strategy at Blue Origin.

The test was conducted under a Space Act agreement for the second round of NASA's Commercial Crew Development (CCDev-2) effort to spark a commercial transportation industry for human access to low Earth orbit. The company did not enter a proposal for the Commercial Crew Integrated Capability round of the agency's seed-money spending, but Alexander says it will continue to develop the space

vehicle and a launcher to carry it to orbit.

Earlier this month, the company conducted a full-pressure, full-duration test of the thrust chamber for the 100,000-lb.-thrust BE-3 liquid-hydrogen-fueled rocket engine that it aims to use for the main and upper stage of its planned reusable booster system.

Although early flights of the biconic space vehicle are slated to launch on an Atlas V, eventually the new booster will carry the commercial crew vehicle to low Earth orbit, according to Alexander. In keeping with past company practice, Alexander did not reveal the source of the solid-fuel "escape system" motor or other technical details. "We're just talking about major milestones when we achieve them," he says.

Three Intercepts for New Missile Exercise

Preliminary results show that the Missile Defense Agency scored three of five attempted missile intercepts in the first integrated flight exercise to combine engagements from three different defense systems.

Both non-intercepts were targets that were engaged by the Aegis ship USS Fitzgerald employing Raytheon SM-3IA missiles. Despite what MDA officials call a "nominal" SM-3IA flight, the missile failed to intercept an Aegis Readiness Assessment Vehicle-B short-range ballistic missile. MDA officials will say only that

a second interceptor "engaged" a BQM-74 cruise missile target.

The Army's PAC-3 detected, tracked and intercepted two separate targets, a short-range ballistic missile, thought to be a foreign military asset (meaning an actual threat missile acquired from abroad), as well as an MQM-107 cruise missile. The new Lockheed Martin Terminal High-Altitude Area Defense system also detected, tracked and intercepted a C-17-dropped medium-range ballistic missile. MDA's largest trial, Flight Test Integrated (FTI)-01, was conducted at the Kwajalein Atoll and Reagan Test Site in the Pacific on Oct. 24.



\$151 million for the Rolls-Royce BR725 engine used on the G650, for which Spirit builds the nacelle.

PROPULSION

Fourth X-51A To Fly

The U.S. Air Force Research Laboratory plans to fly the fourth and final Boeing X-51A WaveRider hypersonic engine demonstrator in mid-2013. Tests began on Oct. 26 on an actuator suspected to have caused the early end to the third flight in August. If confirmed, the fix should be "pretty simple," says the X-51A program manager. The fourth flight will be the last chance for the X-51A to prove that a hydrocarbon-fueled, fuel-cooled scramjet engine can accelerate a missile-class vehicle to near Mach 6.

ROTORCRAFT

Helo Suspensions

Offshore operators of Eurocopter AS332 and EC225 Super Puma helicopters are reviewing health and usage monitoring system data before determining whether the aircraft can be returned to flight. Some AS332s were to begin flying on Oct. 26, but flights of EC225s remain on hold. The suspensions, and a European Aviation Safety Agency airworthiness directive mandating that vibration data be checked, follow the Oct. 22 ditching of an EC225

in the North Sea. All 19 onboard were rescued after the ditching, which was caused by a loss of main-gearbox oil pressure almost identical to the May ditching of an EC225.

USAF Restarts Helo Contest

In the latest attempt to replace its aging Sikorsky HH-60G Pave Hawks, the U.S. Air Force has released the request for proposals for its Combat Rescue Helicopter, providing insight into changes made in a bid to make the program affordable and avoid a repeat of the CSAR-X combat search-and-rescue debacle. The requirement is for 112 aircraft for up to \$6.8 billion.

SPACE

NanoRacks On Kibo 'Porch'

NanoRacks plans to launch its new external commercial research platform to the International Space Station in 2014, for deployment through the Kibo airlock to the Japanese module's exposed facility. The NanoRacks platform completed an interim design review in September, and is headed for a critical design review in April. That will set the stage for delivery to the station. The external platform will hold 10 standard NanoRacks research enclosures.

Spacewalk Scheduled

NASA plans a Nov. 1 spacewalk to ad-

dress a long-standing cooling system leak outside the International Space Station that has gradually increased since June. Earlier concerns about an external electrical short on Sept. 3, which compromised one of the station's eight power channels and prompted the preparations for a possible second near-term spacewalk, have eased with troubleshooting this week.

Small Vision Cited

NASA's vision for deep-space exploration may be missing an opportunity to re-fortify the agency's long-running but sporadic ties to nanotechnology, according to an assessment from Rice University's Baker Institute for Public Policy. Breakthroughs in nanotechnology could hasten bold missions, while fostering advances in energy, medicine and other fields crucial to U.S. economic health, according to the study report, which urges more focused oversight of U.S. nanotechnology research by the White House and Congress as well as multi-year investments from NASA in peer-reviewed arenas to establish and sustain expertise.

Correction: The Oct. 15 Washington Outlook item "Satellite Showdown" (page 25) misidentified Rep. Adam Smith (Wash.), who is the top Democrat on the House Armed Services Committee.



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COMMENTARY

Chasing Airbus

ADI goes all-in on A350 wing titanium machining

The big names in commercial aircraft manufacturing no longer have Southern California addresses, but the area abounds with suppliers. Twice as many aerospace engineers, mechanics, technicians and assemblers work in California as in any other state, and the bulk of them are clustered from Los Angeles to San Diego.

Airbus has made headlines with its plans to begin delivering A320s in 2016 from a factory it will build in Mobile, Ala. The company has an engineering center in Wichita, draws on a new Spirit AeroSystems factory in Kinston, N.C., for the A350 and, of course, could not power its A320s without General Electric in Cincinnati or Pratt & Whitney in East Hartford, Conn. To keep pace with a 4,400-aircraft backlog, Airbus spends \$12 billion annually on parts, components, tooling and services from more than 400 suppliers in 40 states. Of that, more than \$1 billion is spread among 100 suppliers in Southern California.

With the company planning to double its U.S. spending in the next 15-20 years, Airbus has about 20 people on the road to attract, recruit and evaluate suppliers, says Airbus North America Chairman Allan McArtor. Supplier conferences are big draws, both for supplier executives and politicians eager to talk to any major manufacturer about jobs. Airbus uses the forums, such as one Oct. 19 in L.A., both to discuss opportunities on its new programs—the A350 is the big draw—and explain what it takes to do business with Toulouse.

Aerospace Dynamics International, a specialist in large, complex machined parts and assemblies, has learned how. When it started in 1989, the A330 was



ADI's launch program and Airbus has been a steady customer ever since, mainly for its widebody programs. Part of the Marvin Group, ADI's machining skills are used for multiple programs, from making solar panels for the International Space Station to bulkheads and wing spars for Lockheed Martin's F-35. ADI supplies machine parts for all of Boeing's commercial programs, as well as the articulated bomb bay doors shipped to Spirit in Wichita for the 737-derived P-8 maritime patrol aircraft.

Although Boeing is now its largest customer, ADI has a special relationship with Airbus, says President John Cave. "Airbus got us into major lean [manufacturing]," he says. "We really went into a training process by Airbus with our people."

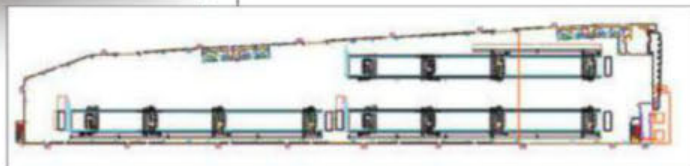
Three years ago, Airbus asked ADI to increase its titanium-processing capacity by 40% with a 120,000-sq.-ft. expansion for producing gear beams and under-wing pylons for the A350. "We've been talking consistently" since

then, says Dave Williams, Airbus vice president for procurement.

Not only talking but designing. With an eye to optimizing the plant's efficiency, Airbus designed specific parts of it, "taking care of what we need [for production] plus risk-mitigation for capacity," he says. The two partners celebrated the building's ground-breaking a day before the big L.A. supplier conference. "We will have the first machine operating 47 weeks from today," Cave promises. The expansion is to cost \$80 million, about half of it in machine tools.

The computer numerical-controlled (CNC) milling machines that ADI is buying from MAG IAS of Erlanger, Ky., are so large that the 746-ft.-long, 140-ft.-wide building will require a 6-ft.-thick and 25-ft.-wide concrete foundation.

Three five-axis MAG computer-controlled milling machines will be built on 300-ft.-long beds (see illustration) for ADI, increasing its titanium machining capacity by 40%.



There will be three 300-ft.-long MAG XTi gantry profilers, adding 60 five-axis spindles to ADI's titanium machining capacity. Cave says they are the largest machines of their kind in the country and will enable ADI to sustain a production rate of at least 13 shipsets per month. That means milling 26 titanium beams a month, about one a day.

Cave says the initial contract represents a \$1 billion program and will make Airbus his biggest customer. To find talent to sustain it, ADI partners with the College of the Canyons in Santa Clarita under California's Centers for Applied Competitive Technologies (CACT) workforce training program. ADI hosts classes at the factory, giving students the opportunity to learn using production-line CNC machines.

"I think it's quite unique," Williams says of CACT's approach. "It gives machines for guys to work on, to gain practical knowledge. [That is] one of the biggest challenges we have in the industry today." ☐

AEROSPACE DYNAMICS INTERNATIONAL



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COMMENTARY

Math and Maintenance

Finnair seeks fix to component problem with out-of-the-box thinking

Finnair had a problem that cost it about €100 (\$130) per minute and it needed a solution.

The culprit was the dual engine bleed air system on its Airbus A330s. The airline suffered two incidents because the system failed—each malfunction resulted in loss of aircraft pressurization and resultant emergency descents.

Finnair flies its eight A330s and A340s about 19 hr. per day “so even a one hour delay can cause a mess for a week,” says Manu Skytta, assistant vice president of component services for Finnair Technical Services. Over the last 12 months, the airline has logged about 20 hr. of delays with these aircraft due to the bleed system so a solution definitely was needed to ensure that these airplanes would be able to produce the high-dispatch reliability rates they are noted for.

Skytta wondered if the airline could use the parameters from the bleed-monitoring computer to forecast bleed system faults and component removals. It had the data but needed

to figure out how to detect anomalies in aircraft subsystems so it could “predict as many critical events as early as possible,” without generating false alarms, ideally with a signal-by-signal approach, he says.

Enter Frankfurt Consulting Engineers (FCE), a company that develops mathematical algorithms to improve industrial production. One of its tools is Hazard Predictor—a data-driven condition monitoring system that uses algorithms to detect deteriorations.

Seeing its problem growing worse,

Finnair decided to put its faith in math because something needed to be done. “The longer a critical event lasts, the more critical it is,” says Skytta.

Finnair started sending raw aircraft signal data via a file transfer protocol server and asked FCE to figure out what was wrong with the aircraft’s system, even though the company has no aircraft background. Just to emphasize

this point: FCE’s employees are highly intelligent, but they are not aircraft engineers or maintainers.

FCE received the flight data weekly, input it into its condition-based monitoring tool, analyzed the data clusters and sent Finnair weekly reports detailing which aircraft parameters included anomalies that could become critical.

Between May 1 and Sept. 13, Finnair removed 26 components related to the bleed system in its A330 fleet—11 of them related to the bleed system computer. Of those 11, the problems

were associated with high-pressure bleed valve (three), bleed valve (two), check valve (two), bleed monitoring computer (one), trim air valve (one), trim air pressure valve (one) and air supply valve (one).

Not to pick on Airbus, but the Hazard Predictor forecast the first warnings of each of these problems before the manufacturer’s Airman aircraft health monitoring system did, and sometimes, Airman did not provide a warning at all.

Nathalie Willig, a project manager for Airbus’s customer services operation, says Airbus is working on its predictive techniques with Airman.

Skytta says Finnair only focused on these eight aircraft’s bleed monitoring computers for six months as a proof of concept to see if it resulted in fewer component removals and maintenance-related delays. While he believes the Hazard Predictor “shows clear potential for specific systems and components,” Skytta acknowledges that a bigger fleet over a longer time period should be tracked.



JAMES R. ASKEW/AVIATION

Finnair and FCE are looking for other airlines that might like to be part of the next stage of this project. Airlines should contact Daniel Jaroszewski, project manager for aviation monitoring systems at FCE Frankfurt.

Skytta says Finnair might want to use this type of monitoring for its Airbus A321s and A350s on order.

With new aircraft and engines offering so many health-monitoring parameters, it is good that airlines are devising new ways to use that data to increase reliability. ☺



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COMMENTARY

Unwelcome Silence

A legacy with roots in aviation's golden age

It came as no surprise. He was 95, after all. But word of his passing Oct. 18 was jarring nonetheless. Legendary characters—and Albert Lee Ueltschi was that—are not easily let go. I've long regarded FlightSafety International's founder as the industry's Last Lion, and Lord knows, he could roar.

He was the youngest of six siblings raised on a dairy farm in Benson Valley, Ky., where there was little money, no electricity and plenty of chores. But even in the hinterlands, news of the era's daring aviators came through and little Al confided in his father that someday he'd become a pilot.

His father's reaction, he recalled, smiling:

"Son, you already are a pilot. After you clean out the stalls, you take the manure and you pile it here and you pile it there."

With a keen eye for opportunity and profit, Ueltschi opened a hamburger stand, Little Hawk, near the Frankfort high school, and used the profits for flying lessons, earning his pilot's license at 16. Later, he used Little Hawk as collateral to buy his first airplane, a Waco 10, while he was still a teenager.

After a disinterested semester at the University of Kentucky, Ueltschi took off to make his way in aviation, initially living hand-to-mouth as a barnstormer, before becoming chief instructor at Cincinnati's Queen City Flying Service.

That stint was notable for one flight during which an aggressive half-snap roll demonstration to a tentative student pilot left Ueltschi hurling groundward without an airplane. The suddenly solo student made it home without further incident, whereas Ueltschi parachuted into a briar patch, tattering his clothing and ego and igniting expletives.

In 1941 came his golden opportunity, flying for Pan Am. Although



its routes spanned the globe, Pan Am was then prohibited from operating domestically. Accordingly, Juan Trippe, the airline's storied founder, conducted his frequent trips to Washington, Florida and elsewhere in a private aircraft. And although one of the carrier's most junior pilots, Ueltschi was chosen to fly it.

Because of that unique role, over the years that followed, Ueltschi rubbed shoulders with financial and political movers and shakers, gaining rarefied advice and insights into the workings of business. Meanwhile, because of Ueltschi's dual role as corporate and airline pilot, he saw that many professional, non-airline pilots lacked the high level of recurrent training demanded of their air carrier counterparts.

So in 1951 Ueltschi set up office in the Marine Air Terminal at LaGuardia Airport in New York, directly across from his Pan Am hangar, and began Flight Safety Inc. While Trippe endorsed the company, Ueltschi bankrolled it by mortgaging his house, and he continued to work for Trippe full time, running Flight Safety after hours.

The clientele grew slowly, but the situation accelerated with the arrival of the first rudimentary simulators, which Ueltschi rented by the hour from the airlines. Then came his boldest move, getting corporate flight departments to pay up front for a Link simulator Flight Safety would purchase and use exclusively. They

did, and the company had its focus.

Ueltschi retired from Pan Am in 1968 when Flight Safety went public; he simply walked out of Trippe's hangar and up the stairs into his office next door. He was there for much the rest of his life—tireless, demanding and driven.

Three key developments skyrocketed the company, renamed FlightSafety International. First was the arrival of the business jet and the insistence by insurance companies for simulator training. Second was the digital processor, which greatly enhanced simulation. And third was Ueltschi's success in teaming with aircraft manufacturers, who made FlightSafety training a part of the purchase price.

Ueltschi went on to create Power-Safety and MarineSafety for the nuclear power and maritime industries, respectively, but ultimately divested those to concentrate on aviation. Meanwhile, the company expanded into military and airline aviation training, which continues, and into making its own simulators.

A man of strong opinions and language, Ueltschi's ripe exhortations could strip paint. And yet I've watched incredulously as he'd charm visitors, my wife included, the perfect gentleman in manner and speech. And while he was famously flinty with a dollar—a fancy lunch was tuna sandwiches at a diner—Ueltschi gave millions of his own fortune to launch and sustain Orbis International, a flying ophthalmology teaching hospital, housed in a DC-8 and later a DC-10. In 2010 he founded HelpMeSee with his son, Jim, to address the problem of cataracts in the developing world.

Ueltschi saw his company grow into a global force in aviation training. Then, one day in 1996, Ueltschi shared burgers and cherry Cokes with Warren Buffett and liked the latter's manner and plans. That December, with Ueltschi's endorsement, FlightSafety became a subsidiary of Buffett's Berkshire Hathaway. Ueltschi remained as chairman and president until Bruce Whitman, his long-time, trusted No. 2, was named to the top positions in 2003, where he remains.

Cantankerous, canny and bold, Al Ueltschi was a continuum of aviation's golden age, the last of its lions. And all in aviation, and beyond, were beneficiaries from his special roar. ☼



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COMMENTARY

Making Markets

Space companies finding the RFP comes too late

Northrop Grumman is prime contractor on the James Webb Space Telescope, but its most notable play in the human-spaceflight arena was the Lunar Excursion Module that landed six crews on the surface of the Moon. Now, as NASA awaits the outcome of the upcoming U.S. elections to begin laying serious plans for human exploration beyond low Earth orbit, the company is encouraging a step past the International Space Station (ISS) into the space around the Moon, including the second Earth-Moon Lagrangian point (EML2) that has advantages as a gateway for travel deeper into the Solar System (*AW&ST* Oct. 8, p. 26).



TELEDYNE BROWN ENGINEERING

"We see that as something that will help the space program along," says Fred Ricker, Northrop Grumman vice president for advanced programs and technology.

It will also help the space industry along, and Northrop Grumman executives make it clear they are eager to compete for new exploration business from NASA—and other government agencies—to keep their workers working and shareholders satisfied.

In an era of tightening federal budgets, the space industry is finding it can't afford to wait for the government to come calling with new business. So industry leaders are pushing

new destinations, such as EML2, and promoting other new markets as well.

"In my opinion, the traditional markets have changed," says Rex Geveden, president of Teledyne Brown Engineering and other Teledyne units. "There was a time when engineering services was a good business for NASA and missile defense. That's a much more difficult competitive milieu these days. A lot of that work has gone away, and those resources have been diverted to other things like commercial launch. So it's been a strategic thesis of ours to go and try to create some of our own future."

Five years ago, Brown Engineer-

ing—"an engineering business with a robust manufacturing capability" in Huntsville, Ala.—drew three-quarters of its business from missile defense and NASA work. Today, Geveden says, that has dropped to a third, and the company is moving beyond its traditional customers into non-space fields such as submarine-carried subsensors for U.S. Navy SEAL teams.

One NASA-related business that fits into the company's new paradigm is the planned Multi-User System for Earth Sensing (Muses) that it is developing as a commercial platform to ride on the ISS (see illustration). Based on the flight-releasable attachment mechanism (FRAM) platforms that Teledyne Brown builds for the space station exterior under a more conventional NASA contract, Muses will provide precision pointing and other accommodation for high-resolution digital cameras and Earth sensors provided by customers from industry, academia and the government.

"We are developing that platform," Geveden says. "It's going swimmingly. We are in mature discussions with probably 10 different entities, mature discussions with probably five and high levels of interest from up to 15 different parties to fly instruments of various types on the platform. I think we'll close a deal pretty soon."

Teledyne Brown Engineering plans to ship the completed Muses platform in the fall of 2014 for integration into the unpressurized "trunk" of a Space Exploration Technologies Dragon on a resupply mission that probably will be launched in the first quarter of 2015, Geveden says. But like the Dragon, the Earth-observation platform will be a private commercial operation, supported by the paying customers who use it.

"That's a Teledyne Brown capability and a Teledyne Brown property," he says. "That's not being developed to deliver to NASA. That's our commercial activity, and we hold title to that platform."

If it all goes as planned, Geveden says the Alabama company will make other proposals for commercial space activities "in the very near term."

"We've got a thousand ideas," he says. "We're fleshing them out now." ☛



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COMMENTARY

No Tanks, We're Cyber

Pentagon ponders two sets of attack rules

The Army's top man in Europe says U.S. forces will have fewer tanks and more cyberweapons as they prepare for post-Afghanistan operations. Visiting Washington, Lt. Gen. Mark Hertling said that U.S. Army Europe has created a deployable anti-cyberforce from the 5th Signal Command and the 66th Military Intelligence Brigade stationed in Wiesbaden, Germany. Explaining the decommissioning of two armored brigades, "We're not lined up against the Warsaw Pact," he says. "We're fighting a lot of stuff, but it ain't the Cold War."

EPH/LANDOV FILE PHOTO



'We're fighting a lot of stuff, but it ain't the Cold War.'

LT. GEN. MARK HERTLING

That may be where the clarity stops when it comes to cyber. The Pentagon is busy finalizing the most comprehensive changes in seven years in the ability to launch offensive operations. But it is tough to figure out how to operate in the

still-new realm. Look for the discussions to produce two sets of rules. One would be for strategic cyberattacks, where a big concern is second- and third-order effects, the cascade of collateral damage that could occur in an ever-networked world. The other would cover tactical engagements, where effects are more predictable and limited. The problem is that the Army has not even produced the requirements for its tactical cyberweapons yet, says Army Cyberspace Command chief Lt. Gen. Rhett Hernandez. "There are gaps in the requirements," he says. Tactical cyberweapons could complicate war-fighting. "[They] will produce an impact on strategic operations," says Lt. Gen. Donald Campbell, Jr., the commander of Fort Hood, Texas, and III Corps. "We have to ensure discipline at each level. But I'm not sure we will ever clearly define the [borderline between the two]."

WARNING: CLIFF AHEAD

While defense companies and their high-profile trade organization, the Aerospace Industries Association (AIA), have been vocal all year in begging lawmakers to avoid automatic budget cuts known as sequestration, set to start Jan. 2, the A&D sector encountered blowback recently for focusing on doomsday job losses that no one wants while not offering much to help lawmakers find a political solution. Now, dozens of CEOs from America's biggest corporations, including many aviation and defense-related companies, are calling on lawmakers to strike a deal to address growing U.S. debt that includes spending cuts and possibly tax increases. A group letter from the CEOs on fixthedebt.org says, besides reforming Medicare and Medicaid and bolstering Social Security, the plan should "include comprehensive and

pro-growth tax reform, which broadens the base, lowers rates, raises revenues and reduces the deficit." The group includes the chiefs of Alcoa, Airlines for America, Delta Air Lines, Eaton, General Electric, Honeywell, Textron and United Parcel Service. Boeing's CEO is there, too, but absent so far are the chief executives from the other four top U.S. defense contractors. But over the summer, a few of them started telling lawmakers similar things. For instance, during a contentious July hearing in the House Armed Services Committee, Pratt & Whitney President David Hess said, "Everything has to be on the table at this point."

WHAT CLIFF?

When it comes to hyperventilation about the looming "fiscal cliff," the airlines have been relatively quiet. Over the summer, the AIA brought together executives from airports and business aviation, aviation safety advocates and former Transportation Secretary Norman Mineta to outline the potential damage that sequestration would wreak on the FAA. The aviation safety agency could lose 1,500 air traffic controllers, safety inspectors and delay the NextGen modernization of the air traffic system, the "biggest change to our aviation system since radar," says AIA President Marion Blakey, a former FAA administrator. Noticeably absent was a representative of the nation's major airlines. The leading trade group for the airline industry does not foresee disaster in the potential of \$1 trillion in across-the-board budget cuts over a decade. "No one knows what might happen should sequestration occur," says Jean Medina, a spokeswoman for Airlines for America, adding that the group was encouraged by President Obama's Oct. 22 debate assertion that sequestration "will not happen." Medina says, "We remain confident that the FAA would continue to ensure the safety and efficiency of air travel. We believe the FAA has the resources to implement our near-term NextGen priority, which is to expedite deployment of performance-based procedures at the nation's busiest airports and carry out demonstration projects with airlines to help make the business case for longer-term NextGen projects like ADS-B-In and Data Comm."

Airbus Scramble

A350 final assembly begins and Airbus asserts that future schedule milestones will be met

Jens Flottau **Toulouse**

The future of Airbus is riding to a large extent on the success of its new A350 widebody, designed to compete head-to-head with Boeing's hugely popular 787 and 777. And while final assembly is underway at last, the European airframer still faces major challenges before the first jet is delivered in 2014—and even before first flight next year.

Last week, Airbus gathered suppliers and customers here for the official opening of the A350 final assembly line in what is now called the Roger Beteille building. The facility will be used initially for the full final assembly process of the aircraft, until another hangar across the tarmac is added in 2014 to expand capacity. Beteille, 91, was one of the founding fathers of Airbus in the late 1960s and a key figure behind the development of the original A300 and, more than a decade later, the introduction of fly-by-wire technology for the A320.

But marking this corporate history was hardly the primary motivation behind the event: Airbus is trying to reassure suppliers and customers that the A350 remains on track for first flight in the



summer of 2013—and on time for delivery in the second half of 2014. The aircraft manufacturer officially opened

the A350 final assembly line alongside a supplier conference. "Our message is: The program is on plan and the upcoming major milestones will be on plan, too," Chief Operating Officer Guenther Butschek said.

Suppliers have noted with concern two issues surrounding the program: Airbus's decision to introduce weight improvements and changes in several batches, which leads to extra work and some performance shortfalls for early models, and the recent wing-drilling troubles that have led to delays for later aircraft, although not for MSN1. A350 program chief Didier Evrard told suppliers that introducing the aircraft in batches is a normal process.

Some issues that have historically caused trouble in programs such as the A340-600 or the A380 will only become relevant next year. Cabin installation is

The first wing for A350 MSN1 has arrived in Toulouse. The second is expected before the end of October.

one such area, and suppliers are already scrambling to make specification changes on time to meet targets mostly related to weight reduction.

Airbus has attached the wings to the first A350 fuselage, MSN5000, which will be used as the static test aircraft. It is currently placed in one of the two Stations 40 that are dedicated to wing-body-joining work. The fuselage of MSN1 is adjacent to it, at Station 50. One of the wings for MSN1 has arrived and is in the final assembly hangar next to the fuselage. The other is expected to arrive early this week.

Powering Up

Final certification tests loom as first Trent XWB rolls out of pre-production site

Guy Norris **Derby, England**

Airbus A350 customers have been reassured by the sight of a Trent XWB engine strapped to the wing of an A380 flying testbed. However, to Rolls-Royce this outward display of progress is just the tip of the iceberg as it works on certification and ramping up production of the first flight-test engines for the new twin.

Rolls is poised to complete the final round of certification tests of the Trent XWB-84 for the A350-800 and -900, and has also frozen the design of the higher-thrust Trent XWB-97 for the A350-1000—the most powerful production engine Rolls has ever developed. As sole supplier for the A350, which has orders for 558 aircraft from 34 customers,



According to Evrard, Airbus has built five wings using a manual process since it discovered that software glitches in the automatic process were causing delays. Four of those wings were intended for MSN5000 and MSN1. A fifth wing is at IABG for initial load-testing ahead of the actual fatigue tests here. Evrard says the software issues caused the first automatic drilling to take around 2-3 months per wing, when it was supposed to have lasted only one month. But for MSN3, the next aircraft in the assembly process, the automatic drilling is "back on target" and Airbus has progressively reduced the manual work.

Evrard also points out that at least the first two flight-test aircraft will be kept at Airbus and no decision has been made whether to keep MSN2 and MSN4, the subsequent aircraft. Airbus plans to assemble two aircraft this year and start producing a third before year-end. In the second half of 2013, it will aim for a production rate of one aircraft per month. "Ramping up production will be crucial," Evrard says.

Airbus plans to roll out the first A350 (MSN1) in April, though it has not specified when the aircraft will make its first flight, aside from saying it expects to reach that milestone next summer.

Work is progressing on a second assembly hall that will allow Airbus to increase production rates starting in 2014. Initial assembly is performed in one hall that includes four stations, three of which are duplicated: Station 50 for fuselage assembly, Station 40 for wing-to-body-join, and Station 30 for systems-testing and cabin installation

MSN1 will be the first A350 to fly. It is slated to make its initial flight next summer.

Once the second hall is completed, the two Station 30s will move to it and another two will be added. Two more Station 40s will be added in the current building in the freed up space.

That space is needed as part of the ramp-up to producing 10 aircraft per month that is scheduled to be reached in 2017. A majority of those aircraft could actually be allocated to the largest version, the much-revamped and delayed -1000. "We expected around 40-50 aircraft per year, but we will be much better than that," Airbus CEO Fabrice Bregier says. If that decision is made, Airbus will also have to invest more into dedicated A350-1000 facilities, he concedes. Bregier insists that Airbus will build all three planned versions, even though he admits that customers have "less appetite for the -800," the smallest variant. "The market will move slightly to bigger aircraft. But we are observing that trend with other models, too," he says.

Airbus would not be Airbus if it could do without politics. The German government is withholding up to €600 million (\$778 million) in refundable loans for the A350 for which the other governments involved (of Spain, France and the U.K.) have given the green light. Berlin wants further assur-



JENS FLOTTAU/AW&ST

ances about the German workshare in the A350 and is concerned that sites in the country might lose out in the long term. It recently blocked the proposed EADS/BAE Systems merger on the same grounds and seems to be taking a tougher stance on industry control than it has historically done. Germany also wants to acquire 15% of EADS from Daimler, although the intricacies and possible legal implications are complex and difficult to resolve.

Bregier says Germany's decision will not cause delays or put the program at risk. However, government-backed financing would help Airbus rule out risk, even if it comes with interest rates that are higher than usual. ☛



Rolls also knows that within six years the XWB engine will be produced at the rate of one per day—the fastest for any Trent.

For Rolls this means a high tempo of work on three fronts—certification, design and production readiness. "Overall we're pretty pleased with where the program is," says Trent XWB program director Chris Young. Since powering up the first engine in 2010 and starting flight tests on the A380 flying testbed in February 2012, the program has aimed to incorporate lessons learned

The core of one the first engines due to be fitted to the A350 is prepared for mating with the fan case.

into the initial engines while clearing the round of certification tests in good time for flight tests on the A350.

The first set of engines for the initial A350-900, the first of the family to be developed, will be shipped to Airbus around the turn of the year. First flight is scheduled for next year with entry-into-service set for 2014.

The immediate focus is on ironing out potential issues in a specially developed pre-production area where Rolls is building the flight-compliance engines that will power the A350 test fleet. The work is vital to "proving out the industrial system," says Young. "We're starting to get there in volume."

It is here that the company has put

the final touches to a “training” Trent XWB, designated Engine 21001, as a key element of its preparations for the initial production standard flight-compliance engines to follow. “We invested in this specific engine, which is completely error-proofed and showed we could do it,” says Young. The engine has been used to prove tooling and train the fitters who have begun assembling parts for the first four flight-compliance engines. “Now that we’ve assembled it we will test it and take it apart again, and built it again several times. That way we are constantly improving our knowledge of how to do it.” Next, it will be handed to the repair and overhaul group for their input, he says.

In all, Rolls plans to make 16 flight-compliance engines, 10 of which will be dedicated to A350 flight-testing. One is the already assembled training engine,

three will be spares, and a further pair will be built for contingencies.

“We’ve taken a middle bay in our maintenance, repair and overhaul site to replicate a full-scale production facility,” says Tim Boddy, head of XWB marketing. “Here we are testing pre-production best practices in a similar way to Bombardier’s preparations for the CSeries, and we’ve taken lessons from automotive manufacturers like Toyota and Mercedes. We have even borrowed some of their guys to help us with Six Sigma [manufacturing improvement] practices.”

The pre-production phase is “a unique opportunity to construct the engine in a single space and get the overhaul guys who work here to come over and tell us about improvements for the XWB. It will speed up the maturation process,” says Boddy, who adds that the concept was “always baked

into the plan.” Although previously tried out in airframe manufacturing, Rolls believes that combining experimental, production and MRO elements into the engine development at this stage, and at this scale, is a first. “We think this is the only dedicated pre-production facility for an aero engine in the world,” he adds.

With certification imminent, there are few changes likely between the training engine and the final standard—which this unit will itself help define, says Young. “In the core engine, it is 99.95% to the final design standard. For the dressing [engine accessories around the exterior], it is probably 90% of the final standard. As always, you tend to find things for weight reduction and maintainability as you progress into production. So even now you can optimize the design,” he adds. Despite the dramatic strides in virtual assembly and digital design techniques, Young says that “there is nothing quite like a final physical verification. We are close to finishing the last [certification] test well before flight.”

One of the final checks was a strain-gauge test of the low-pressure turbine (LPT), which was completed in mid-October at one of the company’s two indoor test sites in Derby, designated the 57-bed. This was done to confirm a minor redesign of LPT aimed primarily at durability improvement, and it followed earlier tests using X-ray images of the engine while running at cruise condition. “We found the blade position was not quite adjusted right and we produced a 0.95% specific fuel consumption (SFC) improvement by changing shims,” adds Boddy.

The certification finale is the dramatic fan blade-off test, which will be conducted in the adjacent 58-bed. A final spin rig test to clear the way for the blade-off evaluation is due to be run soon in Germany. The blade-off test, in which a fan blade is deliberately detached while the engine is running at maximum thrust, will take place “a few weeks after” the test in Germany, says Young. The timetable “assumes we have nothing to analyze from it,” he adds.

Other big-ticket certification tests such as medium- and large-flock bird-

Festooned with orange wiring for flight-test, the fan case for the first flight-compliant Trent XWB for the A350 is readied in a special pre-production area at Rolls-Royce.



MARK WAGNER/AVIATION-IMAGES.COM

strike evaluations were completed earlier this year. "Both passed perfectly, and we just finished certification tests on the bill of material following the 150-hour triple-red-line test," Young says.

Final design freeze for the 97,000-lb.-thrust version of the engine for the A350-1000 was accomplished this month when Rolls completed "the Stage 1 exit" for the design. The key design decisions underpinned the company's commitment made last year to boost thrust without a costly increase in the fan diameter. Instead, this will now be achieved by scaling up the core and increasing the flow by spinning the fan 5% faster. The base of the blades will also be redesigned with an inflected annulus to help boost the flow capacity around the spinner.

"We will get more power out of the core by making it bigger and improve the turbine's capabilities to run the engine hotter," says Young, who describes the growth strategy as a combination of technology insertion and increasing overall size. "A lot of the focus is around the hot end of engine and the blade material. We have changed the design style and improved the cooling effectiveness to get a good time on wing," he adds.

Changes for the XWB-97 include the use of next-generation CMS-X4 single crystal materials and anti-oxidation coatings in the high-pressure turbine which will also be shroudless for the first time on a Trent engine. The turbine disc will also be forged from a dual microstructure disc that will provide greater stress capability toward the center of the hub while at the same time exhibiting better creep resistance toward the tips.

Other improvements will include a more sophisticated adaptive bleed system, which is designed to turn off cooling air bleed during cruise when not required. "It is the next step in evolution from the system on the 84K engine," Young notes. The intermediate pressure (IP) compressor features a "rising line" or inner annulus line that increases in radius, thereby increasing the tip speed of the aft stages. The high-pressure compressor is derived from the European New Aero Engine Core Concept program, and is connected to the IP by a swan-neck duct. This performed "significantly" better than expected in earlier tests, adding confidence that it will meet the thrust target of the XWB-97 with no impact on SFC. ☼

HOT AND DUSTY

Guy Norris **Derby, England**

Airbus and Rolls-Royce are keenly aware that Qatar Airways and Emirates, two of the most outspoken and demanding airline customers for the A350, are watching flight-tests of the Trent XWB engine like hawks—particularly as the engine endures the heat and dust of recent flight trials in the Middle East.

At Al Ain in the United Arab Emirates, the latest test version of the engine for the A350-900 was recently brought for evaluation under the wing of Airbus's A380 flying testbed. The evaluation was a "good positive test because it proves the engine has margin in high ambient temperatures," says Trent XWB program director Chris Young. "We put a lot of design features into the engine to make it tolerant to those conditions," he points out.

Manufacturers have been working to increase the lifespan of engines in the Middle East, where sand and dust traditionally block seals and cooling holes in turbines. "Emirates and Qatar are key customers in the Middle East, so we are making the engine tolerant to those conditions," says Young. Bleed air off-takes, for instance, have been designed to ensure they scavenge a supply from the inner walls of the compressor rather than the outer walls. Dust particles tend to centrifuge to the outer walls, so positioning off-take valves on the inner walls places them in cleaner air. In addition, Young says, the cooling holes in turbines have been specially shaped to prevent particles from building up.

So far, the Trent XWB has been flown on 44 test flights on the A380 for a total of 144 hr. This has been divided into two phases, with the baseline configuration flying 24 times for a total of 74 hr. The second engine, incorporating modifications for more extreme operating conditions and additional instrumentation, has been flown 20 times for around 70 hr.

Overall, the engine has performed better than expected in terms of specific fuel consumption, says Young. Initial testing "took the engine around the whole envelope, including high angles of attack, and throttle-slamming. For that work the engine was kept around the Toulouse area. Then we put the higher-modification engine standard on the A380 and conducted the hot environment tests at Al Ain," he notes. ☼

The hot-weather performance of the upgraded Rolls-Royce Trent XWB was tested in the UAE.



Automating To Success

More use of robotics helps Boeing reach its top 777 production rate

Michael Mecham **San Francisco**



BOEING/BOB FERGUSON

Despite leaning out its 777 final assembly line about seven years ago, Boeing considered its goal of producing 100 of the widebody jets per year unrealistic without a significant capital investment. But a combination of automation, process improvements from its mechanics and a push on hiring is making that goal possible.

Last week, a Boeing 777 Freighter, scheduled for delivery to Korean Air next February, became the first airframe to start through 777 final assembly at Boeing's widebody headquarters in Everett, Wash., at the higher rate of 8.3 aircraft per month. That translates to an aircraft leaving the factory for the paint hangar, flight-testing and customer acceptance an average of every 2.5 days, or 100 completions a year. Vice President Scott Fancher, the program's general manager, says the new rate—the highest ever for any widebody aircraft—is the result of preparations that extend from “floor to ceiling.”

With a midsized twin-aisle jet in the 300-400-seat class, Boeing began redefining the long-haul market when the 777 entered service in 1995, and effectively demoted its own 747-400. Except in freighters, the 777 has become the most prevalent type in the long-haul flights where the 747 used to thrive, particularly in transpacific services. Sales are now dominated by the 777-300ER, which entered service in 2004. Fittingly, it was that model that pushed Boeing to the 1,000th-delivery milestone last March when Emirates, the largest 777 customer, took the keys. Sixty-three customers have ordered 1,380 777s.

Airbus is challenging with its A350 series, particularly the A350-1000 that it hopes will be a 777-300ER market killer. Besides considering new models to meet this threat, Boeing's strategy for keeping customers happy is predicated on turning orders into deliveries as quickly as possible.

When Boeing designed 777 production in the late 1980s, its baseline was a maximum rate of seven per month. Even when it began considering a shift to a U-shaped moving assembly line in 2003, that maximum delivery rate remained in place. The emphasis then was on driving in greater efficiency and driving out costs, largely through better tool-and-parts management and improvements to the way parts and assemblies are fed into the final assembly line (*AW&ST* Feb. 14, 2005, p. 60).

In early 2007, when this new production plan was fully underway in Everett's Building 40-26, the company's analysis showed it would take a big investment and at least a 36-month push to raise completion rates beyond seven per month, says the program's director of manufacturing, Jason Clark. So the idea was not pursued, particularly when rates were dropped temporarily during the 2009 recession.

That all changed 18 months ago. A combination of new automated assembly products and a heavy reliance on the payoff of continuous process improvement showed how rates could reach the 8.3-per-month mark in just 1.5 years. Clark says.

Boeing is not revealing what it has invested in 777 production improvements, but Clark says it has steadily

marched toward the higher rate, largely by relying on innovations fed up from the factory floor by Employee Involvement (EI) teams. “It's a little scary, but all change is,” he says as higher rates begin. “I think it's what keeps the team on its toes.”

The 777, which has 50,000 subas-

Fastener holes on Boeing 777 fuselages are drilled automatically by Flex Track, the blue machine crawling along the black tracks. A mechanic verifies and monitors the drilling process using a laptop.

semblies and three million individual parts, introduced Boeing's “Working Together” concept of supplier involvement as well as advanced tooling, such as laser alignment to assist wing-body joins, that greatly improved the fit of the final product.

Still, Clark says good hand work by mechanics is essential. “Getting an enthusiastic, well-focused, energized workforce is required,” he says. “This is a mechanic-built airplane. These are craftsman-built products. When you come to work motivated to improve and innovate every day, it's amazing what you can become.”

That sounds like a company pep talk, but Clark says Boeing's last contract negotiations with the International Association of Machinists in Aerospace (IAM) “really broke the mold in many ways” for employee involvement. Those talks assured IAM members of jobs in Seattle's Puget Sound region regardless of the company's manufacturing push into non-union South Carolina. IAM leaders have praised the “tone” of the negotiations. The contract “has really turned out to be a discovery [for leadership at the IAM and Boeing] that influenced the workforce significantly,” Clark says.

Boeing's production build-up has added thousands of new hires a year whose inexperience has to be factored into productivity goals. “It takes about 7-8 months for a good hire to be fully trained,” Clark says.

Most of the EI improvements—fleshed out in weekly team meetings—are specific to individual tasks and arise from what Senior Vice President Pat Shanahan calls “the cohesion in their culture.” The 777's origin in a Dassault

Catia computer-aided design means its major build functions were present from the start. That means EI teams are more likely to tackle small issues that eat up time or introduce the possibility of error, such as creating form-fitted plastic covers to protect vulnerable areas in the horizontal stabilizer during its installation or making templates that speed adhesive strip installations.

The employee teams found some bottlenecks that were holdovers from an earlier era. One group that plumbs lavatories was vexed by having to squeeze through a 24 X 20-in. hole to make an adjustment on just one part, a cable guard. When they asked what the guard was for, they learned that it protected a nearby blanket from moisture damage. But a design change had eliminated the blanket, leaving nothing to protect. The cable guard was dropped.

Basic design changes have helped clear onerous tasks that slipped through the design process. Boeing saves 10 hr. by pre-bundling wiring harnesses at its Portland, Ore., fabrication division. Another wiring headache was eliminated in the forward cockpit by developing a bracket that allows a connection to be completed with just four screws instead of working each wire individually.

Boeing also is increasingly turning to automation to speed the build process. Automated drilling machines have been in use for years, but there has still been a lot of hand work, such as thousands of holes in fuselage barrels. Working by hand introduces the prospect of imprecise drilling. In feedback sessions with its airline customers, complaints about nicks, scratches and blemishes around fastener holes were common. Hand drilling is not popular with mechanics, either. Some of it has to be done from awkward positions, such as reaching up from beneath an aircraft's belly. And it introduces the potential for foreign object damage (FOD) as chips fall free from the drilling process.

Introduction of the Automated Spar Assembly Tool from Electroimpact Inc., in nearby Mukilteo, speeded up one join process. Another, drilling barrel holes, was tackled by a computer-controlled machine that Boeing designed and licensed to Electroimpact. Called Flex Track, it initiates a drill sequence with a master "K hole" and then creeps vertically along a track that takes it around the circumference of the barrel. It is repositioned to creep horizontally along the fuselage as well. The Flex Track

sucks away drill debris as it works, reducing the prospect of FOD. A mechanic monitors the process with a laptop.

Boeing is in initial testing of its newest automated tool, a robotic spray system for the aircraft's wings. Unlike fuselages, which feature each airline's distinctive livery markings and are hand painted in a separate paint hangar after assembly, wings are all sprayed the same gray color in a mini-paint hangar inside the factory before installation.

Within the next six months, Boeing expects to bring a robotic system on line that mechanics will control from outside the paint booth rather than requiring them to be inside the booth spraying from a platform moving back and forth over the wing. 📺

To watch a video showing the process improvements on Boeing's 777 production line and hear from employees using them, check out Rupa Haria's post on the Things With Wings blog at: AviationWeek.com/777rampup



Inching Toward Certification

Development of China's regional jet is extended to 12 years

Bradley Perrett **Beijing**

The ARJ21 program was always supposed to be a learning experience. If people learn when things go wrong, then Comac must be learning a lot, and it is giving itself more time for its lessons.

The internal target for certification of Comac's 90-seat regional jet has been delayed again, to 2014 from the previously scheduled mid-2013, says a program official. Development is therefore now likely to last 12 years, with six years in flight-testing. A key reason for the latest delay is slow progress in flight-testing. Engineers are also attending to avionics bugs and modifying the landing gear, one of many issues arising from changes elsewhere in the design.

Another executive working on the ARJ21 knows of no formal decision to delay to 2014 but says that, given the current state of development and flight tests, the aircraft cannot be certified before that year. It is quite likely to be ready in 2014, however, that executive adds.

While struggling to get the ARJ21 certified, Comac is considering both updating the aircraft, whose technology is aging even before airlines begin using it, and launching another region-

al airliner, say industry officials. In the end, the two ideas might be merged. The idea of improving the ARJ21, most obviously with new engines, has been looked at since around the time of the first flight in 2008.

The other project is sometimes called the New Regional Aircraft. It would follow the C929 widebody airliner that Comac proposes building once it completes development of the C919, a

"Some people say the CAAC is being tougher with Comac than the FAA would have been"

158-seat narrowbody planned for certification in 2016 and intended to challenge the Airbus A320 and Boeing 737.

Among the ARJ21's developmental problems is one emphasized by Comac internally: Coordination with the Civil Aviation Administration of China (CAAC) has not always been smooth. CAAC officials need to attend every test flight, but bringing together the schedules of the aircraft and the personnel from different organizations has not been easy and has delayed progress.

The CAAC has also been learning to

improve its performance in certification programs, and not only in relation to the objective of ensuring safety. It has picked up experience in more smoothly working with Comac and suppliers, too. For example, it has not always been prompt in tasks such as inspecting materials and equipment, says a program official, adding that it can be expected to perform better in the future.

The growing experience of CAAC and Comac is a reason not to think that the ARJ21's problems necessarily foreshadow similar delays in the much larger and more important C919 effort. In working on the C919, Comac has come to understand much more about commercial aircraft design and development than its predecessor, Avic Commercial Aircraft Co., knew during the early work on the ARJ21, the executives point out. The company knows more partly because of mistakes made in ARJ21 development.

Those errors have included a structural weakness—the ARJ21's wing failed a strength test. One change leads to others, some at the insistence of the CAAC, such as modifications being made to the landing gear to meet revised load calculations. Sometimes the program has moved too slowly to address emerging issues, says an official.

"Some people say the CAAC is being tougher with Comac than the FAA would have been," says that official. That should not be a surprise. The Chinese authority, renowned for its conservative approach to safety, is also unusually demanding in the standards it imposes on airframe maintenance, while its requirements for the physical condition of civil pilots are sometimes half-jokingly compared with the national space program's demands on astronauts.

The CAAC and FAA are using the ARJ21 program as an exercise through which the Chinese authority will learn

the ropes of certifying a commercial jet aircraft with Western agencies. Once the process is complete, CAAC certifications will be recognized by the FAA and will therefore be widely accepted in Western markets.

Full-scale development of the ARJ21 was approved in 2002 with the objective of putting the aircraft into service in 2006—and learning how to develop a commercial aircraft to Western standards. Managers soon realized that 2006 was too ambitious, and within weeks the target was slipped to 2007, with a first flight in 2005. When 2007 came around, the ARJ21 was due to go into service in 2009, but it did not fly until 2008, at which time the first delivery was pushed back until 2010. More delays followed. Last year, the target was September or October 2012, but early this year it was bumped to June 2013.

There may have been two bumps since then, as a fourth program official says the latest advice to Catic, the state enterprise responsible for international sales, is that late 2013 is the target. It seems that Catic has been told of one delay but not a second, to 2014.

As a Chinese state organization, Comac is not in the habit of announcing program delays, as a Western manufacturer reluctantly would. It also has good reason not to be quick in letting even its suppliers know that there has been another schedule slip, says an industry official.

"If suppliers think that they have more time, they won't try so hard," says that official. ARJ21 suppliers include Comac shareholder Avic (which builds the airframe), General Electric (CF34-10A engines), Honeywell (flight controls), Parker Aerospace (fuel system), Rockwell Collins (avionics) and Liebherr-Aerospace Lindenberg GmbH (landing gear). All are waiting to book volume-production revenue from their development investment.

Comac Chairman Jin Zhuanglong has criticized Catic for failing to secure many—perhaps any—dependable orders for ARJ21s from foreign customers. Catic's response is that Comac, having no record as a supplier of serviceable airliners, needs to certify the ARJ21 first. Operations by the Comac-owned first customer, Chengdu Airlines, should help, too.

Some in the industry are concerned that Comac is losing interest in volume production of the ARJ21 and will be satisfied if it just achieves certification, supporting the C919. But the company has ordered parts for at least 13 aircraft, of which only the first four are prototypes not intended for airline service. It is, therefore, committed to building at least nine production aircraft.

The original ARJ21 program envisaged building 340 aircraft for sale to Chinese airlines. There were to be exports, too, but partners put much more faith in the domestic sales, which the Chinese government could force.

In assessing whether to use the ARJ21 as the basis for the New Regional Aircraft, a key issue is likely to be the size of the new model and the current airliner's body cross section, which accepts five-abreast economy seating and therefore could be stretched to fit 150 seats in two classes. For that reason, the ARJ21 would more likely be the basis for an aircraft that would compete against the Bombardier CSeries or Sukhoi Superjet 100 than for one with fewer than 100 seats.

Comac has said the cross section, unusually wide for ARJ21's 90 single-class seats (or 78 in two classes), was chosen for passenger comfort. But the real reason is that the ARJ21 is generally based on the five-abreast McDonnell Douglas MD-82, built at the same Shanghai factory in the 1980s and 1990s. The ARJ21 is not an exact copy, however. ☉



ARJ21 flight-testing began four years ago. It still has two years to go.

If Only

Mitsubishi's MRJ is in demand but not supply

Bradley Perrett **Beijing**

How Mitsubishi Aircraft must regret the delay of its MRJ regional jet program. When the ink was barely dry on its April announcement that first delivery would be up to two years late, the company signed a preliminary agreement to supply 100 of the aircraft to U.S. carrier SkyWest.

Then SkyWest Airlines said it would quite like to order more than 100 MRJs. More recently, partly because of the endorsement from SkyWest, interest from North American carriers is stronger than ever, says Mitsubishi Aircraft. If only it had plenty of early production slots to spare. If only it could begin delivering aircraft late next year, as originally planned, instead of late 2015, or even early 2016, as now promised.

Like any manufacturer that has told customers their aircraft will be late, Mitsubishi Aircraft is looking at whether it can ramp up production faster than it planned when it launched the program in 2007. But the company is going further than that. It hopes it can increase the maximum production rate beyond the scheduled five aircraft a month. Yet it is also concerned about causing new foul-ups by being too aggressive. The industry well remembers the chaos that resulted from Boeing's over-eager attempts at ramping up 737NG production in the late 1990s.

The intended order from SkyWest, which Mitsubishi Aircraft expects to be finalized this year, will considerably increase the challenge of clearing the backlog, says Hirohide Takaseki, director of strategic planning in the project management office. Pending a final contract from SkyWest, Mitsubishi Aircraft has orders for 65 MRJs from All Nippon Airways (15) and Trans States Airlines of the U.S. (50). Indonesian lessor ANI Group Holdings has said it will order five more. If the intended orders are realized, then Mitsubishi Aircraft will have 170 MRJs to deliver, almost three years of production at full rate, not counting options—and not counting further orders, which can only be inhibited by the difficulty in making early deliveries.

The program delay was a result of a foul-up in the documentation that was supposed to detail exactly how the aircraft was made. The mistake has led not just to a need to make parts again, which airframe builder Mitsubishi Heavy Industries (MHI) has begun doing, but also in engineers having to check documents against the production process specifications.

Completing this task and getting production fully underway is the biggest challenge facing the program, says Takaseki. The company has hired engineers from abroad and borrowed others from friendly manufacturers, he says. He declines to name the companies that have come to its aid but says they have been keen to help the project out of its troubles, which he attributes simply to inexperience.

Another factor may have been in internal communication. Mitsubishi Aircraft has now set up a project management office to promote communication and cooperation among the various engineering divisions. Industry sources say that the Japanese company's Chinese rival, Comac, is suffering from stove-piped organization in which teams are reluctant to work together and tend to push decisions up the command chain.

When programs are delayed, there is usually more than one reason. In the case of the MRJ, the project team fell behind in detailed airframe design, says Takaseki, although that work was completed by the time the delay was announced. From here on, the company expects only normal refinement of the design as it builds and tests the initial units. The first flight is due in the last quarter of 2013.

SkyWest's announcement has also helped drum up interest from other carriers, including North American mainline airlines, he says. While manufacturers commonly play up their chances of imminent

MHI has built this engineering test wing. Now its challenge is to properly document its processes and build flyable parts.

sales, the studies of a rate increase suggest that the company is genuinely concerned it might have more demand than it can feed.

The company would like to shorten the delay but Takaseki does not sound optimistic when he stresses that the priority is on protecting the new schedule.

A longer development program means paying engineers for longer, and in this case pricey foreign engineers flown in to help sort out the problems are in the mix. But the company says it is still aiming at completing MRJ development within the original budget of ¥180 billion (\$2.3 billion).

Mitsubishi Aircraft is not taking advantage of the delay to improve the specification of the aircraft. Engine supplier Pratt & Whitney has, however, rescheduled development of the aircraft's PW1200G geared turbofan to make best use of the delay. Originally running in parallel with the similar engine for the Bombardier CSeries, the PW1200G is now following that larger turbofan, benefiting from its testing and allowing Pratt to spread out its engineers, says marketing director Jim Speich. Some can now work successively on the two engines, rather than side-by-side with colleagues.

While Mitsubishi Aircraft must consider the potential of every supplier to increase its production rate, Speich says Pratt, at least, would have no trouble delivering engines faster. ☐



MITSUBISHI AIRCRAFT

Taking the Long View

French aerospace equipment manufacturers saw steady growth last year, with revenues up 14% to €11.4 billion (\$14.7 billion) and order intake totaling €14.3 billion, including a 20% increase in exports. Olivier Zarrouati, who leads the equipment group at French aerospace industry association Gifas, says the country's equipment-manufacturing industry is entering a new phase. Dogged by a fluctuating but generally unfavorable euro-dollar exchange rate, the rising cost of raw materials and emerging competition from China and Latin America, the A&D supply chain will need to continue diversifying and broadening its customer base to maintain its significant foothold in new international aerospace programs, Zarrouati says. France's aerospace equipment sector comprises almost half of the country's A&D jobs divided among nearly 400 companies. Recruitment this year is on par with 2011, when the A&D workforce grew by 3.2% to 162,000, including 13,000 highly skilled employees. Despite this growth, tougher standards and environmental regulations pose a challenge to France's equipment makers, who, like all European suppliers, can count on very little R&D investment from government. Zarrouati spoke with Aviation Week Paris Bureau Chief Amy Svitak in Paris.

AW&ST: What impact will the new French administration have on A&D budgets in France in the coming years?

Zarrouati: In the U.S., France and Germany, 2012 is an election year, so we are really in a period where it's very difficult to predict what will happen over the long term. The only thing we can predict with a great deal of certainty is that budgets will diminish for defense.

On the commercial side, growth will continue with traffic, and traffic is growing at twice the GDP globally. The only thing is that if it's not growing in Europe or the U.S., it's going to grow in China, and that's it for us.

All in all, the established capacity for manufacturers of large carriers is not enough, globally, to match demand in terms of transportation. So, as long as the economy of the world is growing, we stay optimistic.

Now, when you look at the equipment manufacturers, it's even more optimistic because most of us are now delivering equipment throughout the industry, not only to Airbus or Dassault. The best of us are delivering equipment to Boeing as well—and to Bombardier. If we do a good job, we are going to deliver our equipment to the same category of aircraft and therefore we are neutral to the success of one platform versus another and are able to offset the risk.

Are there key areas for technology innovation within equipment makers

ers that rely on public funding?

We fund our own research—this is one of the reasons why equipment manufacturers deserve a better profit in general than the airframe manufacturers. Over the food chain, some equipment manufacturers enjoy better margins and better operating profits than the airframe manufacturers, and that is justified by, among many other considerations, the fact that they need to fund their own research.

How much does the industry invest in R&D?

The industry has maintained and even increased its commitment to R&D, and it continues to identify new technologies that make products the market will need in 5-10 years and to be more compliant with standardization and environmental measures. About €1.3 billion was invested in R&D in 2010, equivalent to 14% of revenues, 43% of which was funded directly by the companies themselves.

What is the biggest challenge for French industry over the next 10 years?

This industry has been enjoying some help from governments to develop new aircraft. The economic players give back most of the money when the programs are successful. But the industry is supported by the government, and that support is going to pay off in 10 years, because it's a very long-term industry. We need to keep developing industry for the next gen-

ZODIAC AEROSPACE



Olivier Zarrouati

Chairman, Gifas Aeronautics and Defense Equipment Group; CEO and Chairman of Zodiac Aerospace

Age: 54

Birthplace: Toulon, France

Education: Ecole Polytechnique and Ecole Nationale Supérieure de l'Aéronautique et de l'Espace.

Career: Zarrouati joined Zodiac Aerospace in 1998 as head of the remote-transmission flow-metering division, then vice president of external development and later CEO of the aeronautical business. He took over as head of the Gifas equipment group in July 2011.

eration. It would be very tempting for a government that comes into the cockpit with very little money to cut expenses in that regard. But that's a scenario we need to avoid.

A second point is that the government can probably do more than industry regarding the euro-dollar exchange rate. It is a very prominent concern in industry.

Speaking of the next generation, how do equipment manufacturers feel about the availability of highly skilled workers in the coming decade?

We keep needing engineers, and they have to be trained. They have to be educated in our schools, and that is also the job of the government; that's their duty. They have to provide us with the workers needed for the future.

It would be a good idea for the government to convince talented young people that they have a future in their country. Anything that could be done about the tax policy would convince the best talents to stay. ☐

Service at a Price

Competition in unmanned aircraft fee-for-service market brings challenges

Graham Warwick **Washington**

Eleven years of war have built unmanned-aircraft manufacturing into a lucrative business. Operational demands have also created a market for companies to operate the aircraft and provide full-motion video as a service.

As war winds down and budgets follow, interest in UAVs is expanding beyond the military into other government and civilian missions. The industry is anticipating a shift from manufacturing to operating aircraft, but some companies are finding that fee-for-service is a business model with pitfalls.

Textron, parent company of leading UAV manufacturer AAI Corp., has posted a \$14 million charge against third-quarter earnings to cover increased costs on starting up fee-for-service operations with Aerosonde small unmanned aircraft systems for both U.S. Special Operations Command (Socom) and the Navy.

For Insitu—which lost its incumbency at Socom to AAI and must now

compete with both AAI and Computer Sciences Corp. (CSC) for Navy business—introduction of competition into the fee-for-service market it essentially created with its ScanEagle UAS is particularly galling. The Boeing subsidiary

tries since 2004, logging more than 600,000 combat flight hours with company-owned and-operated ScanEagles. “For the last eight years, we were the only company providing this service. We set the standard and created the business model,” says Ryan Hartman, Insitu senior vice president. “The last nine months have shown our business model and performance are hard to replicate.”

In late February, AAI beat out Insitu for the three-year, potentially \$600 million contract to provide medium-endurance UAS services to Socom. In early March, AAI again bested Insitu to win the first two task orders to provide land-based ISR services to the Navy under a five-year, \$874 million umbrella contract.

“Both competitions required a fairly rapid start-up, and winning both presented a ramp-up challenge,” says Steve Reid, vice president of AAI’s unmanned aircraft systems business. “We had one level of ramp-up in mind and we had to expedite it, to ramp at twice the rate.” This required more personnel and resources, including stepping up its training program to supply more operators.

The contracts required the service provider to start up operations and be delivering 3,200 hr. of video a month within 120 days. “For a new company to get up to speed in 120 days with new equipment and performance

UAS Fee-for-Service Competitors

	AAI AEROSONDE MARK 4.7	INSITU SCAN EAGLE DUAL BAY
Endurance	10 hr.+	18 hr.+
Payload	7.5-10 lb.	7 lb.
Ceiling	15,000 ft.	10,000 ft.
Speed	50-60 kt.	50 kt.
Weight	39-55 lb.	48.5 lb.
Wingspan	11.8 ft.	10.2 ft.

Sources: Manufacturers

is now having to reevaluate the affordability of its business model.

Insitu has provided intelligence, surveillance and reconnaissance (ISR) services for the U.S. and other coun-

On the Button Accuracy

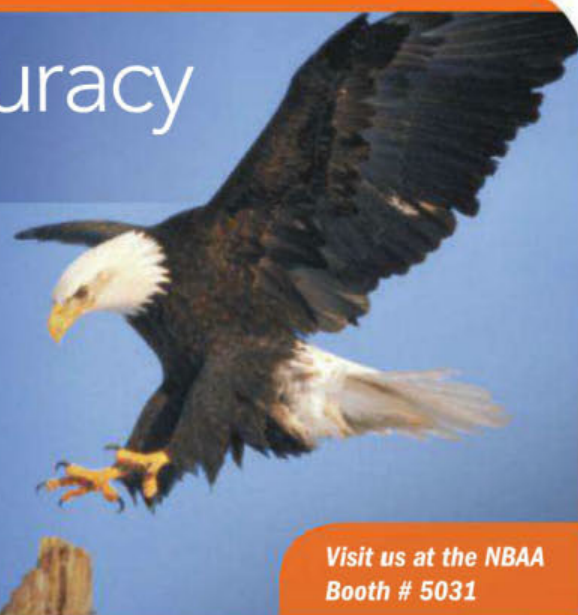
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standards is not easy," says Hartman. "This is not a business to jump into."

Reid says AAI's start-up problems "are in the rear-view mirror" and systems deployed in-theater are "delivering what they need. We have aircraft in the air and are executing." After the charge to cover unexpected costs to start up, the remaining three-quarters under the first year of operations will run at break-even levels, but AAI expects the fee-for-service business to be profitable in the remaining years of the contracts.

"Both customers have awarded task orders as planned," Reid says. Six have been exercised under one contract and two under the other, and two more are expected in the next month or so. "We look at this on an annual basis. We amortize our costs over an annual tranche of task orders. For the first tranche, the loss is behind us."

"Our cost estimates for these programs were based on our extensive experience operating [AAI] Shadow systems for the Defense Department under government-owned, contractor-operated contracts," says Textron CEO Scott Donnelly. "We thought that expe-

rience would be directly transferrable to the Aerosonde platform, but the operating know-how did not transfer well," he told analysts. "We had to augment training, processes and resources and adjust our estimated costs."

AAI has provided UAS services before, using U.S. Army RQ-7 Shadows,

"Cost per hour is an easy metric if you don't have the experience. It's hard to compare price per hour versus the cost to start up."

"but the customer provided the equipment," Reid says. "This time we had to bring everything in—hardware, personnel, tents, generators, everything." Textron announcing the \$14 million charge in October "is an indication of the timeframe it has taken to put in place robust resources" to perform the initial task orders exercised under the two contracts.

For Insitu, loss of the Socom con-

tract and Navy task orders was a wake-up call. The company's success in ISR services with the ScanEagle, Hartman says, has been based on steadily increasing capability, introducing new payloads and improving reliability to meet warfighter needs, even where there are no defined requirements for

continuous improvement. "It has been all about the capability we are providing to the warfighter, not the acquisition community."

But recent ISR service competitions have been won on price, not performance. "The last program awards were

not on performance and capability, but on affordability. Cost has been the Number One evaluation criterion," says Hartman. "Cost per hour is an easy metric when you don't have the experience. It is hard to compare price per hour versus the cost to start up."

As a consequence of the contract losses, "we are working on our affordability, while retaining the same performance," says Hartman. "Our focus is on providing continuous improvement in capability [and in] cost and price. There are areas we have identified for cost reduction, which will reflect in a reduced price."

Although Insitu is structured around the fee-for-service business model, its rapid growth since 2004, and the acquisition by Boeing in 2008, "have allowed inefficiencies to grow into the company," says Hartman. "There are services we thought were important that maybe are not so important and can be trimmed out. We will focus on the vehicle and sensor performance, on the warfighter, and outside of that look for cost inefficiencies."

Reid says delivering a cost-effective service "is very much in mind" as AAI competes for further task orders under the Navy ISR services contract. The Aerosonde is being qualified for ship-based operations—now the preserve of the ScanEagle—and the next battle with Insitu will be for task orders to operate UAS from Navy warships.

"Fee-for-service is a large part of our portfolio going forward," Reid says. "There has been some learning within our parent company and the financial community, but they are pleased we are in this business." ☐



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Better Command, Improved Control

U.S. Army inches closer to goal of integrating sensors and shooters for air and missile defense

Amy Butler Washington

The U.S. Army is finally expecting its first delivery—due next fall—of new equipment designed to help correct the problem of fratricide in its air and missile defense forces that has persisted since the Persian Gulf war in the early 1990s.

The \$2 billion Integrated Air and Missile Defense Battle Command System (IBCS), led by Northrop Grumman, intends to consolidate up to seven disparate command-and-control systems for air and missile defense forces into one. Today, equipment such as the Patriot/PAC-3 and Terminal High-Altitude Air Defense (Thaad) systems and a bevy of sensors and “shooters” effectively operate independently, with coordination happening at higher echelons of Army command in the field.

IBCS, if fielded as intended, will introduce visualization technologies from the gaming industry to allow streamlined command of all of these systems as a network, says Col. (ret) Larry Newman, Northrop Grumman operations research analyst and former air defense officer. And better knowledge of what aircraft are operating in the airspace is key to reducing instances of fratricide that have haunted Army air defense elements in the past. During the most recent Iraq invasion, the Patriot defense system was involved in three fratricide incidents, two of which were against coalition aircraft and resulted in three deaths.

So far, the network will include the Patriot/PAC-3; the new Thaad system; the Joint Land-Attack Cruise Missile Defense Elevated Netted Sensors System (Jlens) aerostat; Surface-Launched Advanced Medium-Range Air-to-Air Missile; Sentinel, AN/TPQ-53 radars and other sensors as well as Stinger missiles. IBCS is designed to integrate Army systems only, focusing on defending airspace close to where soldiers are operating on the battlefield, says Barry Pike, acting Army program executive officer for missiles



PAC-3 radars and missiles will be among the elements linked on a network through the U.S. Army's IBCS program.

and space. But the program is just one step on the path for the entire Defense Department to develop an overarching integrated air picture for commanders. This picture will cover far larger swaths of airspace at a strategic level.

Army officials are expecting their first delivery a year from now to include two IBCS elements for a single battalion-level command system as well as two systems that, deployed separately, will outfit two separate brigades. The size and composition of each IBCS element can vary depending on the echelon of command. The delivery will also include two fire-control relays, which are designed to allow any sensor to feed into any shooter, Newman says.

Though IBCS will not have undergone all its safety tests then, soldiers

at Fort Bliss, Texas, and White Sands Missile Range, N.M., will begin familiarization work and perform various demonstrations, including the passage of data from one sensor—such as the Sentinel—to a shooter—such as PAC-3.

After this early operational capability, the second major delivery milestone to facilitate initial operational capability is set for fiscal 2016 and will include seven more IBCS elements, Newman says. Another tranche of capability is slated for delivery two years later.

The Army's design approach did not entail recreating new code for the linkages among the systems, says Col. Neil Thurgood, deputy Army program executive officer for missiles and space. Rather, Northrop is building off of existing software in each of the systems. Additionally, the service found that large deliveries would be cost-prohibitive because of the need to provide updates to each of the elements already fielded. So, the approach is to incrementally field capability—up to two IBCS, depending on funding—annually. And, as more sensors and shooters are integrated with various fielding plans, the network will grow.

Pike says Army officials have experience in “point-to-point” integration, which involves integrating one particular sensor with one particular shooter—for example, the Jlens cuing a Patriot interceptor. The unique aspect about the IBCS approach is that it creates a network. In the past, the service shied away from this because when any element took on an upgrade, it affected that element's linkage to the system, forcing updates across the network. With IBCS, the Army is wrapping the software and hardware around a set of interfaces and protocols to protect the system from becoming paralyzed when a particular element incorporates an update.

“This is a good start at doing something other than single-point integration,” Pike says.

The technology is expected to prompt the Army to use its existing air and missile defense hardware differently and, likely, more efficiently. “The biggest challenge now is not really technical, it's operational,” Newman says. “We will have more data and information than we've ever had.” Sensors and shooters will be able to be placed at optimal locations now and feed into the larger network. This will allow fewer sensors to supply

more coverage with fewer gaps. Additionally, not as many soldiers will be needed for command and control of the elements because they can be consolidated at hubs on the battlefield—remote from their sensors and shooters, Thurgood says.

The gaming industry's influence shows up in the IBCS's user interfaces

and visual cues. They allow for young soldiers—for whom video games are second-nature—to develop a more intuitive relationship with the systems, Newman says.

But it will also help visually clarify for soldiers exactly who has “ownership” of an airborne target, Thurgood says. This ensures that “the right shooter is shoot-

ing at the right time.” Today, units can overlap engagements of a target, possibly wasting interceptors.

Training can also be streamlined, Thurgood says, because user interfaces are designed with common symbology and cues. Today, a Patriot operator's workstation is different than one for a Sentinel or AN/TPQ-53 radar. ☐

Branching Out

With Pentagon spending on the decline, U.S. defense companies look abroad

Jen DiMascio, Bill Sweetman and Amy Butler **Washington**

The strategy of U.S. defense contractors to grow international sales so as to offset a tightening military budget at home is starting to show results.

Their approach and its effectiveness were both apparent at last week's Association of the U.S. Army conference, a trade show here that revels in its American-ness. Alongside attempts to sell supplies to the next generation of U.S. soldiers, and with the uncertainty of a potential \$500 billion cut to the Pentagon budget, defense companies were talking up brighter prospects of potential sales to militaries across the globe.

The wall of Sikorsky's booth was covered with a world map, color-coded to advertise international sales of Black Hawk helicopters. Raytheon is looking to build on its defense sector's already strong global base of sales. Lockheed Martin is selling components of command-and-control systems abroad, while marketing pieces of

it domestically. And Boeing is at work on an export of its entry for the Armed Aerial Scout program.

With more than half of its sales going beyond U.S. borders, Raytheon's Integrated Defense Systems (IDS) considers itself better positioned than some of its “competimates” to navigate tighter U.S. defense budgets, says President Tom Kennedy. Raytheon, which supplies more than 8,000 programs, is not beholden to one platform such as the Joint Strike Fighter or the DDG-1000 Zumwalt-class destroyer.

International sales account for 25% of Raytheon's business—and 54% of IDS's. Other defense companies are trying to increase their global portfolios, but their starting point could be much lower—around 8%, Kennedy says, making it more difficult to offset declines in U.S. defense spending. “If you have a 10% cut, then you've got a problem,” he says.

Lockheed Martin wants to grow its

sales abroad to 20% from 17% of its business. Boeing's defense division has increased its international sales to 24% in 2011 from 16% in 2009. And Northrop Grumman has held steady at 6% in foreign sales in each of the last three years.

Continued conflict in Syria and elsewhere in the Middle East is driving sales to Gulf Cooperation Council (GCC) states. “There is significant opportunity to provide security and defensive systems for that region,” says Kennedy.

Long relationships are key to Raytheon's international sales in the Middle East, Kennedy notes. Saudi Arabian nationals have worked for the Massachusetts-based company for more than four decades, and Raytheon is helping to create jobs in Saudi Arabia, the United Arab Emirates and Kuwait. The company also works with two suppliers in Turkey, Roketsan and Aselsan, which provides opportunities for more affordable sales and job growth within the U.S., Kennedy says.

This summer, Congress was notified of a possible sale of \$4.2 billion in Raytheon's Patriot missile defense system equipment to Kuwait. The company is competing against Russia and China to sell Turkey the Patriot system, too, for a contract that is anticipated by this December, Kennedy says.

For its part, Lockheed Martin hopes to close a deal by year-end to sell an advanced, automated air and missile defense command-and-control system known as DiamondShield to the United Arab Emirates and another member of the GCC. DiamondShield uses some elements similar to the company's Marine Corps Air Mission Planner but is larger in scope.

The concept behind DiamondShield

In June, Congress was notified of a potential \$1.1 billion deal by Sikorsky to sell UH-60 helicopters to Qatar.



U.S. DEFENSE DEPARTMENT

is to integrate and fuse data from other air- and missile-defense assets, together with own-force information and a terrain database including priority targets for protection. It also incorporates tools for analyzing the battle picture, "auto-weaponeering"—selecting the best weapon to engage each target—deconflicting airspace and planning intelligence, surveillance and reconnaissance missions. The system is intended to feed information to lower command echelons and mobile devices, using a graphic map display to provide an intuitive picture.

Potential customers in the U.S. already have sophisticated command-and-control networks, so Lockheed is likely to sell bits and pieces of the system at home. Abroad, the opportunities could mean hundreds of millions of dollars, as militaries look to install more complete networks. "They want the latest and greatest, and they have the funds to do that," a Lockheed official says.

Saudi Arabia may also provide a market for Boeing's offering for the Army's on-again, off-again Armed Aerial Scout (AAS) program. The Army continues to weigh whether it can embark on the AAS for the same or lesser cost of upgrading its Kiowa Warriors, targeting an average unit product price of \$13-15 million. A decision is expected by year-end, but while it has been waiting, Boeing has developed the AH-6i for the international market with as much off-the-shelf computer hardware as possible. The helo complies with International Traffic in Arms Regulations, allowing for quick approval of foreign sales.

The Army will oversee air worthiness certification for the AH-6i as part of foreign military sales. The air worthiness as well as technology development could be ported to an Army AH-6i, if the service considers it for a Kiowa Warrior replacement.

Roughly 83% of the AH-6i software was pulled from the Apache Block III, says David Koopersmith, vice president of attack helicopters for Boeing. The applications will look and feel to AH-6i pilots much like those of the Apache Block III, he says.

"Affordability will be a unique driver going forward more than it has in the past," Koopersmith says. "The Boeing strategy is a low-risk, date-certain, cost-certain approach." ☐

Radar Secrets

Low-profile radar work is disclosed

Bill Sweetman **Washington**



LOCKHEED MARTIN

An unidentified, classified air vehicle is the primary platform for a compact high-resolution ground-surveillance radar developed by Lockheed Martin and unveiled last week at the Association of the U.S. Army show here. It is intended to provide accurate target and intelligence imagery in bad weather.

The radar has been dubbed Advanced Synthetic Aperture Radar System (Asars) 3. Asars-1 and -2 were developed for the Lockheed SR-71 and U-2R, respectively, in the 1980s, when both were strategic reconnaissance systems operating under tight classification.

The active, electronically scanned array (AESA) radar is much smaller than its predecessors, with an installed weight of only 165 lb., and operates in the K_u - rather than the X-band. That inherently limits its range to 40-60 km (25-37 mi.), according to Mark Grablin, director of airborne reconnaissance systems. But it also leads to a higher resolution of "below 1 ft." that makes it possible to exploit and analyze information more quickly. Those characteristics would suit it for a platform designed for "an anti-access, area-denial" environment, Grablin says, and allow it "to get closer to its targets. Those systems tend to be unmanned."

Asars-3 could be associated with an undisclosed program, or with Lockheed Martin's RQ-170 Sentinel. The U.S. Air Force disclosed the latter's existence in late 2009, but details of the UAV and its sensor fit remain classified.

Lockheed's Goodyear, Ariz.-based

Lockheed Martin is developing an X-band radar reconnaissance pod for an Asian F-15E operator.

unit, which developed the Asars-1 and its predecessors, is handling Asars-3. (The unit, originally a Goodyear entity, was part of Loral before its acquisition by Lockheed Martin.) This historically low-profile group has revealed new details of other SAR projects.

One of these is a strategic long-range radar reconnaissance pod tailored to the Boeing F-15E. The radar, developed for an Asian customer, started flight-tests at St. Louis 18 months ago. The X-band system is intended to deliver 1-meter (3.2-ft.) resolution at more than 50 km range, with a maximum range of 250 km. The customer is almost certainly South Korea, which uses a related Lockheed Martin radar installed on Hawker 800 business jets and developed under the Peace Krypton program.

Lockheed Martin is now talking about an F-16-compatible SAR pod with two other non-U.S. customers.

After demonstrating its Gulfstream-based Airborne Multi-INT Laboratory to the Italian air force, Lockheed is now competing with Israel Aerospace Industries to provide an operational follow-on aircraft, with a large SAR, signals intelligence, electro-optical and other sensors. Italy has ordered IAI's Gulfstream G550-based Conformal Airborne Early Warning aircraft and is looking for a G550-based ground and sea surveillance aircraft to simplify support and pilot training. ☐

Throttling Back

India cuts the number of Fifth-Generation Fighter Aircraft it seeks

Asia-Pacific Staff New Delhi

Slashing its requirement by a third, the Indian air force (IAF) says it will induct only 144 of the originally ordered 214 Fifth-Generation Fighter Aircraft (FGFA) that it is co-developing with Russia.

Significantly, while the IAF had planned for a 214-aircraft fleet, with a mix of 166 single- and 48 twin-seat fighters—the latter to have been developed by Hindustan Aeronautics Ltd. (HAL)—the new requirement will be for all single-seaters, a clean break from previous IAF aircraft purchases. Time and cost constraints have forced the IAF's hand, and it is now virtually certain that a twin-seat version will never be built.

The Indian version, in effect, will be a modified PAK FA fighter that Russia currently has in flight-test. An \$11 billion co-development agreement is expected to be signed in December toward a program that is anticipated to cost both countries a total of \$30 billion. Officials from UAC/Rosoboronexport are due in India imminently for final discussions on the research and development agreement.

Russia's defense minister, Anatoly Serdyukov, who was in India earlier in October, also revealed a three-year slip in the schedule for the aircraft to enter service, to 2020. The IAF had been banking on a 2017-18 time frame for deliveries to begin. The slip also is understood to have forced a reconsideration of numbers and configurations.

A senior IAF officer who is part of negotiations with HAL and Russia says, "Plans to develop a twin-seat version have been shelved for the moment. This helps cut down on development time and cost. There have been apprehensions about delays that HAL may encounter in building a modified twin-seat variant. With the reworked requirement, there is a far better chance of staying on time and cost."

HAL recently revealed a wind-tunnel model of its single-seater, though it remains unclear just how different the Indian version is from the three Sukhoi T-50s now in flight-test, especially since the HAL version will have its own avionics, sensors and weapons, but not modifications to the airframe itself. A team from Russia's Sukhoi Design Bureau is in Bangalore participating in wind-tunnel tests that are set to begin shortly at the National Aerospace Laboratory.

IAF Air Chief Marshal N.A.K. Browne has indicated that his test teams will receive a total of three aircraft in 2014, 2017 and 2019, the last being a final production version of what the government has designated the Perspective Multirole Fighter for now.

Speculation here among analysts and officials that the purchase numbers could have been reduced to accommodate potential interest in the Lockheed Martin F-35A has been denied both by the IAF and defense ministry, which say India's FGFA program is on a course that cannot be changed now.

India's other futuristic fighter project, the Advanced Medium Combat Aircraft (AMCA), is in the advanced design and configuration phase. While the IAF supports the AMCA effort, it has decided to focus its energies for now on the Indo-Russian platform. The AMCA is now significantly different



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The Indian FGFA, in effect, will be a modified version of the PAK FA fighter that Russia currently has in flight-test.

from when it was first unveiled in 2009; its planform and contours have taken on a markedly more Lockheed Martin F-22 Raptor-like design.

"It is envisaged that the Indian FGFA will be an MKI version of what the Russians may ultimately designate the Su-50. The IAF and HAL will have total control over all electronics, systems and weapons," a HAL official, who was part of a delegation to Russia, said recently.

He also denied suggestions that the IAF had made the FGFA decisions because it did not believe HAL could handle such a complex project.

"The new requirement and configuration [was] frozen after the IAF and HAL held detailed discussions on what was and what wasn't possible, keeping in mind very strict timelines. We also have to account for delays on the Russian side," the official said. Russia will supply the FGFA's turbofan engines as well as a full range of stealth technologies, which remain almost entirely unexplored by the IAF and HAL.

An official with the Russian Trade Federation in New Delhi says, "It is important to the Russian government that this program does not falter in any way. The loss of the [Medium Multi-Role Combat Aircraft] competition was big for Moscow. And even though this is a co-development program, we have to work positively to ensure that the aircraft is ready for both our air forces on or before the planned period." ☐

Politics At Play

Three contenders vie to be Malaysia's next ASW helicopter

Leithen Francis Kuala Lumpur

Malaysia's navy is generally last—behind the army and the air force—when it comes to securing budget approval for new aircraft, but the government may be end up giving the navy priority over the other armed services, because anti-submarine warfare (ASW) capability is becoming critical.

The deputy chief of the navy, Vice Adm. Mohammed Noordin bin Ali, says ASW has increased in importance because there are now many more submarines in Asia. He says the navy needs to boost its capability by buying six more ASW helicopters.

China's main submarine base is on the southern tip of Hainan Island overlooking the South China Sea, an area subject to territorial disputes with Malaysia—one of the claimants. China has been adding submarines as have Singapore and Vietnam. Indonesia and Thailand plan to add submarines.

The navy already has six AgustaWestland SuperLynx 300 helicopters, but these lack the equipment to detect deeply submerged submarines. They can only detect them snorkel-

ing, says the navy's helicopter squadron commander, Cmdr. Sazalee bin Shoib. Even though the SuperLynxs are nearly 20 years old and lacking in capability, the navy plans to retain them for training, he adds.

The new ASW helicopters, meanwhile, would be stationed on the six French DCNS-designed corvettes the government has commissioned Malaysian company Boustead to build. Boustead disclosed in December that the first ship will be delivered in 2017. The navy hopes the first corvette and helicopter can enter service simultaneously.

It is considering the AgustaWestland AW159 and Sikorsky MH-60R. The NHIndustries NH90 has been ruled out as too big for the corvettes.

There is, however, a dark horse. Sources within the navy say EADS subsidiary Eurocopter has pitched the idea of a naval variant of the EC725. The EC725 could fit on the deck, and there would be commonality with the air force's 12 EC725s on order, says a senior source in the navy. The services could share resources such as spare parts and support. The navy may have to equip its vessels to support the EC725 anyway, because the air force wants to land its EC725s on the navy's vessels during disaster relief missions, say industry executives. Sazalee, however, declined to comment.

At TangentLink's ASW conference in Kuala Lumpur earlier this month, Sazalee gave a presentation detailing the ASW requirement. He says the navy wants a 6-10-metric-ton helicopter that has a composite airframe and blade, fly-by-wire flight control system and "single-engine return to home capability." He also says the helicopter must have deck-securing, powered folding and traversing systems, so it can be moved to and from the deck.

As for sensors, the helicopter must have 360-deg. tactical radar, multiple track-while-scan and inverse synthetic aperture, automatic radar periscope detection and discrimination, forward-looking infrared integrated with radar and navigation systems, a dipping sonar, sonar buoys, electronic warfare suite, integrated friend-or-foe interrogator and data link, he says. The navy's vessels and helicopters presently use the Link Y MkII data link. Among the issues the Malaysian armed forces face is the need for a common data link.

Sustainability and maintenance are the service's real concerns, particularly with a small navy, Rear Adm. Pahlawan Syed Zahiruddin Putra Bin Syed Osman, told the conference. Maintenance and customer support will be key considerations when selecting the new ASW helicopter, says Sazalee.

The fact that Eurocopter and AgustaWestland have customer support and maintenance centers at Kuala Lumpur's Subang Airport means each manufacturer has a strong card to play. Sikorsky, however, has yet to follow suit. Sources in the navy say Sikorsky needs to boost its maintenance and customer support presence in Malaysia, if it is to win. As with Eurocopter, that means partnering with a local company. Boustead announced in December it was establishing a joint venture with the EADS subsidiary for helicopter maintenance.

Sikorsky may be holding back because it is waiting for the

government to allocate a budget for the helicopter procurement and include it in the country's five-year plan. The consensus in the industry, however, is the government is unlikely to allocate a budget for the helicopters until after the next elections, which are due to be called in March.

Sikorsky also may be waiting to choose a local partner

U.S. Navy MH-60R deploys its dipping sonar. Malaysia is considering the MH-60R for anti-submarine warfare.



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until it sees how the political landscape unfolds. After all, one of the advantages of having such a local affiliate is it can help win over key government decision-makers.

It is unclear, however, who will be calling the shots after March. Malaysia's prime minister, Najib Razak, is the top decision-maker and his coalition party UMNO, which has been in power since 1959, is widely expected to be returned to power. But if UMNO is reelected with a much reduced majority, it will be considered a poor election result for the party; undermining Najib's leadership and potentially sparking a leadership change. ☐

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Kerosene Heavy

Space Launch System eyed as the platform for a new U.S. hydrocarbon rocket engine

Frank Morring, Jr. **Washington**

Before the dust settles from the post-shuttle shift in human access to space, the U.S. could find itself with a big new high-performance hydrocarbon rocket engine to boost NASA's planned heavy-lift Space Launch System (SLS) off the pad. There is a chance it might even replace the Russian-built RD-180 that carries the United Launch Alliance Atlas V.

A dual-use rocket burning refined petroleum-1 (RP-1), a form of kerosene, instead of liquid hydrogen or solid fuel, might hit the sweet spot in next-generation U.S. space launch needs. It could give NASA enough thrust to build its congressionally mandated 130-metric-ton heavy lifter, while removing Russia from the critical path to launching sensitive national security payloads.

"We know the [Defense Department] is interested," says Dale Thomas, associate director-technical, at NASA's Marshall Space Flight Center. "They are a little apprehensive about using a foreign-sourced engine on a strategic capability for our nation."

Thomas helped set up the National Institute for Rocket Propulsion Systems (Nirps) at Marshall to find ways to strengthen the U.S. industrial base in the field. One of the Nirps projects is finding "intersecting interests" for collaboration in rocket propulsion, and large hydrocarbon engines may fill the bill.

"We have to have higher lift capabilities out of the Space Launch System, and it turns out one of the options we are looking at is RP-based engines, which potentially intersect with the core-stage engine for the Atlas V," Thomas told the Fifth Von Braun Memorial Symposium in Huntsville, Ala., this month.

NASA is in talks with the Air Force

about joining the Hydrocarbon Boost Technology Demonstrator program, a relatively low-level Air Force Research Laboratory (AFRL) effort to develop advanced kerosene rocket technology. Among the AFRL contractors on the program is Aerojet, which is developing a 1-million-lb.-thrust, LOX-rich staged combustion kerosene-fueled engine designated the AJ-1E6 that could fill the civil and military roles, accord-

ordered (*AW&ST* Oct. 22, p. 34). The talks are complicated by the need for agreement among the Air Force, NASA and the company on how best to proceed, according to Rex Geveden, president of Teledyne Brown Engineering, a Huntsville-based supplier that has an agreement with Aerojet to manufacture components for the new engine.

"There is more complexity in this one because there are multiple players," says Geveden, a former associate administrator of NASA, stressing that his company is not involved in the talks directly. "There is some potential Air Force funding and some things like that going on that make this at least a three-party discussion."

NASA has already awarded Dynetics Inc. of Huntsville a \$73.3 million

study contract to demonstrate components of an Apollo-era F-1 kerosene main engine, updated with modern manufacturing techniques, as the engine for the advanced boosters, as well as a separate contract with ATK on new versions of the solid-fuel boosters that launched shuttles into space, and with other companies for technology that could help provide the needed extra lift for SLS.

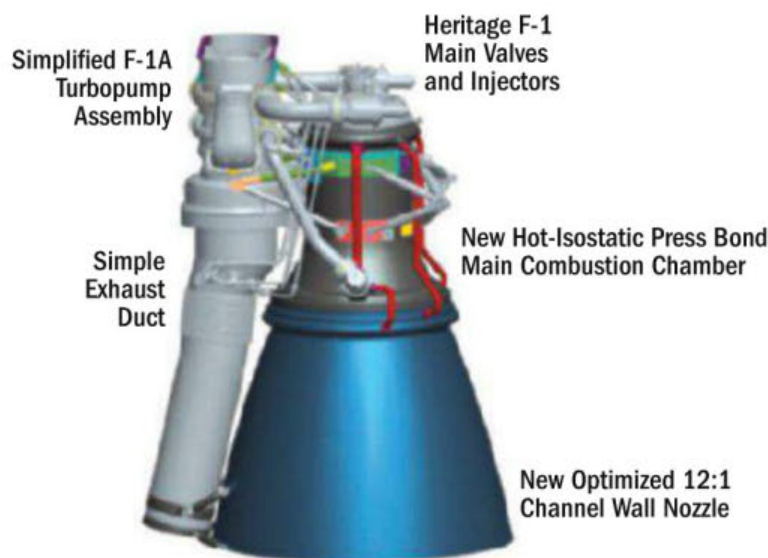
According to a paper presented at the recent 63rd International Astronautical Congress in Naples, Italy, an upgraded F-1 would provide more than enough capability for the SLS application, and could power other vehicles that might even serve

as a U.S.-powered replacement for the Atlas V.

Lead author Steve Cook, director of space technologies at Dynetics, wrote: "The high-cost, non-recurring engineering typical of engine development was accomplished during the Apollo-Saturn program, eliminating significant risks (e.g., turbopump design and combustion stability). This permits the current focus to be on affordability rather than technical feasibility."

In the Dynetics concept, two of the F-1 engines originally developed for

SLS F-1 Engine Configuration



- 1,800,000 lbf. Sea Level Thrust
- Capable of Continuous Throttling to 1,300,000 lbf. Sea Level Thrust
- Robust Gas Generator Cycle

Source: Dynetics

The Dynetics concept of a Saturn F-1 engine is upgraded for Space Launch Systems (SLS) via modern manufacturing.

ing to Julie Van Kleeck, the company's vice president of space and launch systems.

NASA is negotiating with Aerojet to bring the AJ-1E6 into the mix of potential powerplants for the advanced boosters it must develop to raise the SLS from its 70-metric-ton initial capability to the 130 metric tons Congress

the Saturn V first stage would drive twin strap-on 18-ft.-dia. SLS boosters, using shuttle-heritage attach struts and other hardware to save more on development. The engines would use vintage-design F-1 valves and injectors, and simplified F-1A turbomachinery, with modern Hot-Isostatic Press (HIP)-bond construction for the channel wall main combustion chamber, and a channel wall nozzle (see illustration).

The F-1 remains the most powerful U.S. liquid-propellant rocket engine ever built, and with the proposed modifications it would deliver as much as 1.8 million lb. thrust at sea level, throttlable back to 1.3 million lb. thrust, according to Cook's paper. If used on the early version of the SLS, without the planned upper stage powered by the J-2X version of the Saturn J-2 upper-stage engine, it would be able to generate 105-metric-ton capability, Cook and his coauthors wrote.

Dynetics has teamed with Pratt & Whitney Rocketdyne (PWR), which built the original F-1 and J-2, and is developing the J-2X. Although Aerojet is in the process of acquiring Rock-

ettyne, the two companies remain competitors for now with their different approaches to the SLS booster engines, according to PWR President Jim Maser.

A significant difference between the modernized F-1 and the AJ-1E6—itself a modernized version of the Russian NK-33 engine Aerojet acquired to power the Orbital Sciences Corp. Antares launch vehicle—is the engine cycle. While the F-1 is a gas generator, which vents part of its propellant over the side after using it to turn the turbomachinery, the AJ-1EJ is a closed-cycle staged combustion engine that burns all of the propellant. Aerojet argues that the closed cycle makes its engine more efficient, while Dynetics says the gas generator's lower operating pressures allow the use of less expensive materials and components.

Before joining Dynetics, Cook was program manager for the Ares I crew launch vehicle that was canceled along with the rest of the Constellation program of shuttle-replacement human-rated vehicles. While the F-1 upgrade is not intended to power the Atlas V, a "single-stick" configuration

using one F-1-powered booster and an upper stage, just as the Ares I used a shuttle-derived solid-fuel first stage, could more than match the Atlas V lift capability.

"The F-1 is not a plug and play for an RD-180 on an Atlas V," Cook says. "However, our dual-engine booster, combined with an upper stage, can deliver over 30 metric tons to orbit—a single-stick version of an EELV-heavy."

The former NASA engineer argues that the F-1 modification is aimed at affordability, since the capability is already inherent in the design. Under its 30-month advanced-booster study contract, Dynetics and Rocketdyne plan to hot-fire-test the modern F-1 powerpack at Stennis Space Center to demonstrate its performance and reduce risk.

"Think booster versus engine application," Cook says in an e-mail. "We are engaging the larger space launch community (e.g., commercial, Defense Department) about applications beyond SLS and we have had interest from several parties. When you plan to hot-fire the key components of the largest engine ever built in the U.S., people get pretty interested." ☛

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Air Astana has been adding new Embraer 190s to expand its network in Central Asia and the Caucasus.

The Next Frontier

IATA chief calls EU ban on Kazakh and Kyrgyz carriers a 'misguided' approach to safety

Leithen Francis Astana, Kazakhstan

Central Asia has the potential to be the next boom market for international air travel, but the European Union's blacklist is keeping a damper on the market.

While Kazakhstan and Kyrgyzstan are the only Central Asian countries with airlines on the EU blacklist, International Air Transport Association (IATA) Director General Tony Tyler says the blacklist has imposed a stigma on the whole of Central Asia. It has also adversely affected "the connectivity of countries here and the business of all airlines operating in Central Asia," he told Aviation Week at an IATA conference here last month.

Tyler says the EU's blacklist is a "misguided approach that does little if anything to improve safety." He also says "there is no transparency—no clarity—on why some carriers are put on the list and no clear indication of what is required to get off the list."

All Kazakhstan-designated carriers are banned from EU airspace, with the exception of national carrier Air Astana, which is 49% owned by BAE Systems. Air Astana was given this concession because its fleet is registered in Aruba, a Caribbean island that is an autonomous member of the Netherlands. The airline, however, is only allowed to operate to Europe using the aircraft it had before the ban was imposed in July 2009, and it is forbidden to increase services to Europe.

"Some aspects of how the [blacklist] is administered are absolutely absurd," Tyler says. It makes no sense why Air Astana should be prevented from flying its newest aircraft to Eu-

rope, he says, asking, "How could that possibly improve safety?" The EU ban was issued three months after Kazakhstan's civil aviation authority, the Civil Aviation Committee (CAC), failed an audit by the International Civil Aviation Organization (ICAO).

Beken Seidakhmetov, CAC chairman, says ICAO has agreed to come to Kazakhstan and that the CAC hopes to pass the ICAO audit by the end of 2013.

ICAO says in an April 2009 statement that "two significant safety concerns were identified in the area of aircraft operations and aircraft airworthiness, pertaining to the issuance of air operator certificates and certificates of airworthiness" in Kazakhstan.

The country has more than 13 commercial airlines, according to the Aviation Week Intelligence Network (AWIN), which means the regulator needs more staff to provide proper oversight. ICAO recommended that "Kazakhstan implement measures necessary to enhance the ability of its civil aviation authority to recruit and retain qualified and experienced inspectorate staff."

Seidakhmetov says the government responded in July this year by increasing CAC salaries. The hope is that if CAC personnel are well-paid, the authority can retain them and attract new, highly qualified talent and mitigate corruption. As one industry executive said on the sidelines of the IATA conference, "You need to pay people a good salary, because if you don't, they will find other ways to earn income."

As for the large number of air operator certificate (AOC) holders, this continues to pose a challenge; but

rather than cancel some certificates, the CAC is taking a different tack. Seidakhmetov says all Antonov An-24s and Yakovlev Yak-40s will be removed from the aircraft registry by November. He says there are 60 Western-built and 52 Soviet-built aircraft on the registry today.

Most of the Western-built aircraft are operated by Kazakhstan's two largest carriers, Air Astana and SCAT Airlines, while the Soviet-built aircraft are spread across a plethora of small airlines. According to the AWIN database, the An-24 and Yak-40 account for 28 and 13 aircraft, respectively, so banning these types could effectively ground many small carriers.

In a separate development, the government has allocated 1 billion tenge (\$66 million) for 2012-15 to modernize 10 of the country's airports, says Seidakhmetov. He also says the government will soon assign one operator for all the airports. Industry executives say Kazakhstan's national rail company is likely to be chosen.

Tyler warns that the capacity at Kazakhstan's main international gateway, Almaty International Airport, "lags well behind the threefold increase [in traffic] that has occurred since 2004," when the airport was last upgraded. "Plans are in place to build a new terminal capable of handling 2,500 passengers per hour. That will provide some relief, but we need to think strategically and beyond that to ensure the economic opportunities are not artificially constrained by a lack of infrastructure," he says.

Kazakhstan's aviation infrastructure also needs to extend beyond Almaty and Astana, says Tyler. "Of the 20 airports in the country, only 10 comply with ICAO standards. In some cases, the deficiencies are as basic as the equipment and trained staff for firefighting, deicing and security. In Uralsk, the runway is in such a state that commercial services are no longer possible," he notes. ☐

Buy and Diversify

AirAsia looks to raise cash via IPOs and launch 'a few more airlines' in next six months

Leithen Francis Singapore

"I'm not Richard Branson," says Tony Fernandes, co-founder and CEO of the AirAsia Group, when asked about the similarities between him and Branson. "I have zero interest to go to the Moon. My sense of adventure is more down to Earth."

Fernandes, who worked for Virgin Records in the U.K. and counts Branson as a personal friend, says the Virgin Group boss is a serial entrepreneur. Branson establishes a business, then finds people to manage it for him so he can move onto the next venture; says Fernandes, noting, "I like to manage the business."

Aviation industry insiders, however, are increasingly wondering how Fernandes finds the time to manage his sprawling empire.

He spoke with Aviation Week here last month, where he was watching his Caterham team compete in the Formula One Grand Prix. Caterham is also the name of a British sports car-maker Fernandes bought last year. He owns English Premier League club the Queens Park Rangers and is the founder of Southeast Asia's basketball competition, the AirAsia Asean Basketball League. His Tune Group, meanwhile, owns international budget hotel chain Tune Hotels, Malaysian financial services firm Tune Money and Malaysian mobile phone network Tune Talk. But AirAsia is the business on which Fernandes spends the most time.

AirAsia Malaysia has a fleet of 59 A320s; its Thai and Indonesian affiliates have 25 and 21 aircraft, respectively. It has also established an affiliate in the Philippines, which began operating March 28, and one in Japan, which started up Aug. 1. "Everyone says doing business in Japan is difficult, but I think it's easy. AirAsia Japan made a profit in its first month and will make a profit this month," he says. AirAsia Japan's business partner is All Nippon Airways.

But doing business in the Philippines is another story. "I am finding it tough in the Philippines," he says, adding that AirAsia Philippines is com-



Tony Fernandes owns an auto maker and F1 racing team, as well as an English Premier League team and the Tune Group of businesses in addition to running AirAsia Group.

peting against two larger and more established carriers, Cebu Pacific Air and Philippine Airlines. AirAsia Philippines only has two aircraft, but industry executives say Fernandes is speaking to Alfredo Yao, the owner of the country's third-largest carrier, Zest Air, about buying his airline. Fernandes declines to comment on this.

AirAsia tried to buy Indonesian carrier Batavia Air this year, but the deal fell through after AirAsia performed due diligence on Batavia. AirAsia declines to say publicly why it scrapped the deal. If it had followed through with the \$80 million acquisition, it would have gained some additional air traffic rights and slots into Jakarta's Soekarno-Hatta International Airport, as well as access to Batavia's pool of travel agents. But it would have also taken on Batavia's liabilities. Fernandes says AirAsia planned to replace Batavia's fleet of old Boeing 737s with new Airbus A320s, and that the leases on the 737s were due to expire within the next two years. However, returning aircraft to leasing compa-

nies can be an expensive exercise.

AirAsia, meanwhile, was planning to source the A320s from its own order backlog. The airline has received 100 of the 175 A320s it ordered several years ago, and last year it signed for 200 more, a mix of A320s and A320NEOs. Fernandes says the AirAsia board is deciding about ordering another 100 A320/A320NEOs.

Thai AirAsia CEO Tassapon Bijleveld says the rationale for buying another 100 narrowbodies is that the 200 ordered last year are largely to replace the 175 received a few years ago. AirAsia has a policy of retiring aircraft at 12 years of age. Since it ordered the 175 A320s, the group has established airlines in Japan and the Philippines, Tassapon notes. AirAsia plans to launch "a few more airlines" in the next six months, says Fernandes, without elaborating.

South Korea news reports say AirAsia is considering buying T'way, a small low-cost carrier that the government-backed Korea Deposit Insurance Corp. (KDIC) has put up for sale, after the airline's majority owner, Tomato Savings Bank, was suspended last September. KDIC has since sold Tomato Savings Bank but is still trying to find a new owner for T'way.

While AirAsia appears to be on an acquisition hunt, it is also planning to raise cash via initial public offerings. Fernandes says Indonesia AirAsia will issue an IPO next year on the Jakarta stock exchange. He also says that "if the board agrees, this December AirAsia X will do its IPO" on the Kuala Lumpur stock exchange.

In addition to its medium-haul flights within the Asia-Pacific region, AirAsia X was operating long-haul routes to London and Paris with A340-300s until March, when it suspended the unprofitable services. Fernandes says that in 2015, when AirAsia X starts receiving its A350-900s on order, it will return to Europe. The carrier also has two A330-200s on order that it no longer wants. One has been sold to a new customer in a VIP configuration, as will the second, Fernandes says.

Besides raising capital on the stock exchange, AirAsia is speaking to banks to finance its aircraft on order. "Asian banks have more liquidity than European banks. We are trying to get new banks interested [in aircraft financing], particularly banks from Asia," says Fernandes. ☉

COD War

C-2 or V-22? U.S. Navy faces divergent options for carrier resupply

Graham Warwick Washington

An unequal battle is brewing to replace the airplane that has provided U.S. Navy aircraft carriers with their logistics lifeline to the mainland for half a century, a competition that could lead the service to reevaluate fundamentally how it transports high-priority cargo to its battle groups.

Recapitalization of the Northrop Grumman C-2A Greyhound carrier onboard delivery (COD) fleet will pit a remanufactured C-2 against the Bell Boeing V-22 Osprey tiltrotor, with no other obvious candidates. But more than selecting between intrinsically dissimilar aircraft, the anticipated competition will require the Navy to choose between distinctly different operating concepts (conops).

Modernizing the Greyhound would allow the Navy to merge its small C-2A and E-2D Advanced Hawkeye airborne early-warning fleets for significant operating and support cost-savings while leaving the COD mission essentially unchanged. But the V-22's vertical-takeoff-and-landing (VTOL) capability would bring an ability to land on smaller ships and merge COD with the vertical onboard delivery (VOD) mission now performed by slower, shorter-range helicopters.

Affordability is also part of the equation, with Northrop Grumman arguing that the C-2 could be modernized in phases, beginning with the engines and cockpit, to provide commonality with the E-2D. Bell Boeing, meanwhile, points out that the Navy is already part of the V-22 program of record with an unfunded requirement for 48 aircraft that, if procured, would give the Navy and Marine Corps a combined total of more than 400 Ospreys, far larger than the combined C-2/E-2 fleet.

In August, Navy leadership kicked off the program by assigning Naval Air Systems Command's (Navair) deputy assistant commander for acquisition, also known as Air 1.0, the responsibility for standing up a program office to execute the COD recapitalization acquisition strategy. This followed a refreshing of the analysis of alternatives

for the COD mission, which identified two viable options, C-2 remanufacturing and the V-22.

Air 1.0 was chosen because it is not aligned with either of the Navair program offices responsible for the C-2/E-2 (PMA-231) or V-22 (PMA-275). "It's neutral ground," says an industry official. "We are proceeding with COD recapitalization programmatic planning and requirements development for a competitive acquisition program," says Brian Scolpino, Navair COD recapitalization program manager. "We are looking at a Milestone B [development decision] in the second quarter of fiscal 2016."

Northrop's C-2 programs director, Steve Squires, says "the Navy has some seed money in 2013 and '14, so something is going to happen." The 35-aircraft fleet has gone through a service life extension program over the last 10 years that increased airframe life to 15,000 hr. from 10,000 hr., but fatigue and stress issues mean the C-2s will need to be remanufactured or replaced by the mid-2020s, he says.

"One of the difficulties the customer has had is in trying to develop requirements and make assessments of the V-22 versus the C-2, because they are so different," says Joe Weston, Boeing senior manager, V-22 business development. "We are looking at a change in conops with the V-22."

Today the Navy has a hub-and-spoke operation, using C-2s to fly time-critical parts and supplies from logistics bases on shore directly to the carriers. The twin-turboprop aircraft can fly up to 1,300 nm, carrying 10,000 lb. of cargo or 26 passengers. Once delivered to the carrier, loads are broken up and parts forwarded to other ships in the battle group using VOD helicopters.

With its long-range, high-speed VTOL capability, "the V-22 can deliver directly from where the materiel is held to where it is needed—it can go to a smaller ship first, then the carrier, then another ship," says Weston. While the C-2 can fly in daylight only and typically does not stay overnight on the carrier,



U.S. NAVY

the V-22 can fly cargo day or night, he says, adding that "the C-2 mission is solely carrier onboard delivery of cargo and people. Once there, the V-22 can do other things."

One potential "overnight-stay" role is as an aerial-refueling tanker for carrier-based aircraft, and Bell Boeing is conducting independent R&D on the mission, testing a V-22 wind-tunnel model equipped for hose-and-drogue refueling. Another possible role is combat search-and-rescue, with the Osprey offering higher speed and a 500-nm radius compared with 100-200 nm for the MH-60S helicopter, he says.

"The question is whether this is a combat logistics aircraft or a carrier logistics aircraft," says Squires, arguing that the COD mission is more about replacing warehouse inventory on carriers than resupplying ships in combat. "A Navy ship is its own warehouse, with 30-45 days of parts of supplies. Orders for parts to replace that inventory are not predictable." So the Navy relies on FedEx and UPS to ship parts to shore bases for loading onto C-2s. "That is not like combat logistics," he says.

Squires also points out that the C-2 is pressurized; the V-22 is not, although it is not a key performance parameter for the COD mission. "The C-2 can fly above the weather, almost like a commercial aircraft, which is why pressurization is important," he says. "The Navy is wrestling with this and it could be a requirements discussion that the competition could hinge on."

Bell Boeing, meanwhile, argues that carrier operations with the V-22 avoid the "drama" of the C-2's arrested landings and catapult launches. "With the



Today's C-2 (pictured) delivers high-priority cargo directly to the carrier deck from shore logistics bases. The V-22 tiltrotor could fly resupply missions to smaller ships in the battle group.

R&D funds on studies of a 'smart canister' that would fit in the V-22 and not have to endure the same g loads." The module could also be carried externally as a sling load, but at lower speed and range—and with higher risk of losing the load en route, argues Squires.

The issue is a cost trade-off, says Squires. "Everybody struggles with the JSF engine, but the issue is how you spare it. You can have a full and open competition, include it in the requirements and start with a clean-sheet design, or you can take a few extra components on the cruise. The engine is modular and stores easily on the ship."

Although Weston says today's MV-22B is competitive on payload, range and speed with the C-2A, Bell Boeing is looking at drag reductions, such as tip sails on the nacelles, and increased fuel capacity. There is space for additional fuel in the aft right sponson of the MV-22, and other options include conformal tanks and external tanks on stub wings that would be mounted below the wing on each side, he says.

Weston also argues that the V-22's "total ownership cost is very affordable versus the legacy system," but Northrop Grumman believes the C-2's

structure is sound and that only minor repairs and equipment updates would give the aircraft another 20 years of life. "Our recommendation is not to do it all at once, but take a phased approach to keep costs low," says Squires. "The right time to do the engines and cockpit is in the latter half of this decade, but they don't have to touch the airframe until the mid-2020s." At that time, options could range from replacing the wing attach points to building new fuselages.

Merging the C-2 and E-2 configurations would provide a 25% saving in cost per hour, Northrop calculates, with a 15% fuel-saving from upgrading to the E-2D's digitally controlled Rolls-Royce T56-427 engines. The more powerful engines would also allow the C-2 to exceed 1,300 nm with full payload on a hot day, he says. Common configurations would reduce the avionics, engine and propeller spares inventory required on the carrier, as well. "If you merge the configurations, you can fly seven aircraft from the carrier and need only one engine and propeller as spares," Squires says.

If the mission remains carrier logistics, then converging the C-2 and E-2 configurations "is good enough," Squires asserts. It would take the Navy time to become comfortable and change its conops, Weston says, but replacing—or augmenting—the C-2s with the V-22 would bring a new capability to carrier decks. ☉

C-2, the ship has to be rigged for flight operations, which it does not have to do with the V-22," Weston says, adding that eliminating the catapult launch "is significant when you look at medevac."

Eliminating the arrested landing is key to tackling a problem both bidders face: The power section of Pratt & Whitney's F135 engine for the Lockheed Martin F-35 Joint Strike Fighter, in its shipment container, is too large to fit inside either aircraft.

"The power module has to be shipped in a very robust canister or it is not considered ready for flight," says Weston. "But the lower g-loads on the V-22 versus the C-2 mean we may be able to look at a canister that is not as robust. We are spending independent

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Foreign bizjet makers move closer to their customers

William Garvey **Melbourne, Fla.**

When questioned as to why he robbed banks, Willie Sutton famously replied, "Because that's where the money is." Well, international business jet makers are continuing to set up manufacturing, assembly and completions shops in the U.S. for much the same reason: North America has been, is, and is forecast to remain the No. 1 consumer of their products for the foreseeable future.

Embraer is the latest to join the USA-Made club. In 2011, the Brazilian manufacturer opened a \$52 million Phenom assembly, completion and painting facility and business jet customer center at Melbourne (Fla.) International Airport, and delivered the facility's first Phenom 100 that December. It will begin delivering Phenom 300s in 2013 and plans to increase production to eight aircraft per month. The main parts are shipped from Brazil to Florida by boat.

The company says the all-new Melbourne site brings assembly and delivery closer to its U.S. customers—rather than having them travel to Brazil to claim their aircraft and fly it home, hopscotching the length

of South and Central America or the Caribbean. Also, the new location facilitates interaction with its suppliers, an important factor since about 75% of the Phenom's content comes from North America. Moreover, the production facility is just a 3-hr. drive up Interstate Highway 95 from Embraer's North American headquarters in Fort Lauderdale, Fla.

Embraer has more than 200 workers on site at Melbourne and is still hiring. In March, the company announced plans to develop the Embraer Engineering and Technology Center at the airport.



DASSAULT FALCON 2000



Embraer's Global Customer Center is a state-of-the-art facility in Melbourne, Fla. To see a video of it under construction, check out the digital edition of

AW&ST on leading tablets and smartphones or go to AviationWeek.com/embraermelbourne

The center, providing research and development across Embraer's commercial, business and military programs, will eventually bring an additional 200 workers to the Melbourne location during the next five years. That unit is already operating in temporary quarters but Embraer anticipates acquiring additional land at the airport and opening a new R&D facility there in late 2014.

While the Melbourne assembly facility is dedicated to Phenoms only, it holds rights to 150 acres of airport land that seem ideally suited for eventual expansion into Legacy assembly as well.

Gary Spulak, president of Embraer Aircraft Holdings, said of his company, "Where we go, we grow" and for the Melbourne site, "We're still thinking big." That seems to be a shared attitude among club members.

Falcon 2000s are readied for painting at Dassault's Little Rock, Ark., facility.



HONDA AIRCRAFT

Honda Aircraft's roots in Greensboro, N.C., trace to 2000 when the Japanese manufacturer established a research facility at Piedmont Triad International Airport (GSO) for the purpose of researching, fabricating and flight-testing a light jet of its own design.

The site's selection resulted from several factors: its proximity to scores of colleges and universities and their associated Ph.D.s; the 10,000-ft. runway; and FedEx's decision to establish a hub there, thus facilitating overnight delivery of parts. In addition, Honda Aircraft President and CEO Michimasa Fujino had established a good working relationship with the FAA regional office in Atlanta while doing prototype work at Mississippi State University and wanted to build upon that.

Four years later, Honda teamed with General Electric to pursue the development, production and sales of a turbofan engine for the light business jet market—what has become the GE Honda Aero Engines HF120. Expected to be certified soon, that engine will be manufactured at a new facility in nearby Burlington, N.C.

Since then Honda Aircraft has established a state-of-the-art manufacturing, research and administrative campus at the Greensboro airport encompassing nearly 500,000 sq. ft. under its roofs. And in September, it broke ground on a new 90,000-sq.-ft. maintenance and repair facility there, slated for occupancy in 2013.

The company already employs more than 700 people at the Greensboro site. And even though its HondaJet is well

into certification flight-testing, Honda does not anticipate the aircraft's entry into service until the second half of next year, at the earliest.

Arguably, the senior member of the Made-in-the-USA Club is Dassault Falcon Jet—again largely as a result of customer activity. Once he settled upon the Falcon 20 to be his start-up company's first aircraft, Federal Express Founder and CEO Fred Smith had to modify the French twinjet to haul packages. He chose Little Rock Airmotive to do the job of converting the business jet into a cargo carrier by fashioning a large door in the cabin's fuselage. The plan succeeded famously, and FedEx quickly outgrew its Falcons.

Nevertheless, once Dassault decided in the 1970s to move closer to its major customer base and suppliers and outfit and paint its aircraft in the U.S., it turned to the place where workers knew its products intimately and acquired Little Rock Airmotive in 1975.

When Dassault bought it, the Arkansas-based company had a 61,500-sq.-ft. hangar and a core group of highly skilled artisans in cabinetry, carpentry, leather goods, upholstery and a range of other activities. Since that time, the Little Rock base has grown to become Dassault's largest facility—bigger than any in France—employing 1,600 workers. The Dassault plant at Little Rock

National Airport now covers 1 million sq. ft. and, according to the company, has completed "well over 1,000 Falcons."

While the aforementioned are the club's current principals, other international OEMs that had also established major operations in the U.S. have ceded their membership through their acquisition. These include Hawker and Mitsubishi's Diamond Jet, both now part of Hawker Beechcraft, and Galaxy, which was acquired by Gulfstream.

A noteworthy characteristic among those international OEMs who remain independent in the U.S. is their common rejection of locating in well-established aviation manufacturing hubs in, say, Seattle, or in particular, Wichita.

Notably, Embraer, Honda and Dassault (and Hawker, Galaxy and Mitsubishi before them) all established large U.S. manufacturing, assembly or completions operations in southeastern "right to work" states where unions could not exclude or demand dues payments from non-union members. The decision to locate there rather than in a union-strong aviation hub such as Wichita was not by chance.

Said one executive of a new club member, "Why in the world would you go to Wichita and take on all that trouble? You'd be nuts." As he spoke, members of the International Association of Machinists and Aerospace

Workers were striking Bombardier Learjet's hard-pressed facility in Wichita, demanding higher wages and better health benefits. ☐

Phenom 100s await completion at the Embraer facility on Melbourne (Fla.) International Airport grounds.



WILLIAM GARNER/ANIST

Honda Aircraft's 500,000-sq.-ft. Greensboro, N.C., facility houses state-of-the-art manufacturing, research and administrative offices.

Biggest Lear Advances



The Learjet 85 will be the first all-composite business jet.

BOMBARDIER

Beset by a bankruptcy, a bad market and now a walkout, Bombardier perseveres

William Garvey **Queretaro, Mexico, and Wichita**

The Oct. 8 strike by members of the International Association of Machinists and Aerospace Workers (IAM) at Bombardier's Learjet plant in Wichita is merely the latest challenge in the Model 85's development saga.

Launched in October 2007, the mid-sized, Mach 0.82, 3,000-nm aircraft—the largest Learjet yet and the first constructed of composites—was to be jointly developed with Grob, a German company well known for its composite trainers. However, the program was set back when Grob declared bankruptcy in 2008, at which point Bombardier decided to bring all development work in-house.

Subsequently, the Montreal-based OEM switched the composites technology from the wet layup used by Grob to the prepreg material more prevalent in U.S. industry and familiar to the FAA. Several different composites are involved, but the material system selected for the overall airframe is a low-pressure, oven-cured carbon fiber, including sandwiched sections.

To accommodate the new manufacturing process, Bombardier decided to build a new 185,000-sq.-ft. facility at its airport campus in Queretaro, Mexico, where the aircraft's forward and aft fuselage, nose, tail cone, vertical and horizontal stabilizers and wings are molded and large sections mated. However, as all that was underway, the business jet market—and particularly the light and medium jet market—collapsed, and has yet to re-

cover. But Bombardier soldiered on.

While the composite construction offers no weight savings, Bombardier says the material provides a weight-to-strength ratio superior to aluminum, largely eliminates corrosion concerns, reduces parts count, results in a super-smooth and low-drag exterior, allows for bigger and better placed windows, and maximizes interior space.

The completed sections are then trucked 1,400 mi. north to Learjet's main plant at Mid-Continent Airport in Wichita, where the whole aircraft is assembled, and the Rockwell Collins Pro Line Fusion avionics suite, Pratt & Whitney Canada PW307B engines with full-authority digital electronic control (Fadec), and interior are installed. It is here that the exterior is painted and buyers take delivery of their \$19.67 million aircraft.

The flight deck, an adaptation of the Bombardier Vision platform on the Global line, features a three-screen (15-in.) panel, dual flight-management systems with graphical flight planning, auto throttles and dual cursor controls.

Meanwhile, the cabin measures 5 ft. 11 in. dropped aisle to ceiling and 6 ft. 1 in. across, and features: double club, fully berthing seats (one can be switched out for a three-place divan); galley; full aft lavatory, lots of storage; an Ethernet-based cabin management system; and entertainment systems with XM radio, bulkhead and eight pop-up monitors, and iPhone/iPad control.

The fuselage for the first flight-test aircraft was delivered to Wichita in

late August. The company declines to say when that initial flight will occur, but some time in 2013 seems likely. The company is also mum about orders, but the first several units will go to Flexjet, its Dallas-based fractional aircraft ownership operation, which has confirmed nearly 50 shares with deposits in hand. It anticipates delivery of its first Lear 85 in the last quarter of 2013.

The years-long slump in the business jet market has resulted in some unsold inventory, and Bombardier has announced it was "pausing" manufacture of the Learjet 60, with no certainty that the line will ever be restarted. However, if the market for a Model 60-sized aircraft returns, the Model 85's platform could likely be adapted to serve the need.

And despite market doldrums, Bombardier's investment in the light end goes beyond the Lear 85 to include the Learjet 70 and 75, which are follow-ons to the Models 40XR and 45XR, and respectively priced at \$11.1 million and \$13.5 million. Certification and first delivery are expected in early 2013. In May, Bombardier reported orders and commitments for more than 50 of the new models.

Meanwhile, Bombardier is further developing its top-end offerings with the intercontinental Global 7000 and 8000, and is expanding its Montreal facilities to include a new Global delivery center and larger completions center. The \$68.9 million Global 7000 is targeted for service entry in 2016,

and the shorter Global 8000, priced at \$66.3 million, the following year.

To accommodate the Lear 85, construction of production flight, paint and customer delivery facilities will put another 242,000 sq. ft. under the roofs in Wichita. And in Queretaro, what will be a 234,000-sq.-ft. building is under construction for the manufacture of assemblies for the growing Global family.

All that activity in a down market has had an impact on head count. Bombardier employs more than 1,500 workers in Queretaro, approximately 600 of whom are dedicated to the Lear 85 program. Meanwhile, employees number about 3,000 in Wichita, an increase of nearly 50% since 2008, and it plans to add another 600 as Learjet 85 production ramps up there.

The IAM represents 825 of the company's Wichita workforce, and 79% of the voting union members supported the strike. Central to that decision, the union says, was Bombardier's offer for

a wage increase of 4% over the next five years, with no increase in the first year; the elimination of two popular health maintenance organizations; and concerns that alternative plans represent a 110% increase in costs.

Bombardier says it was disappoint-

ed by the rejection of its five-year contract proposal, but plans to continue negotiations to resolve outstanding issues. In the interim, the manufacturer says it has taken steps to minimize "disruption to the production line, its customers and the community." ☐



WILLIAM GARREY/ANALYST

Employees at Bombardier's Queretaro, Mexico, plant work on the forward section of a Lear 85.

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Quiet Skies

Drastic reduction in resolution advisories will be on tap with next-generation ACAS

GARRETT HARRISEN

John Croft Washington

Pilots of business jets, commercial airliners and all manner of general aviation aircraft will fly more safely and experience far fewer collision alerts after 2020 with a family of new airborne collision-avoidance systems (ACAS) the FAA is developing.

Dubbed ACAS X, the technology is the FAA's prime choice as a drop-in replacement for today's required traffic-alert and collision-avoidance systems (TCAS) and will be the foundation for new products in the light and unmanned aircraft sectors.

Unlike TCAS, which at its core is a "deterministic" calculator that uses heuristics built up over decades for selecting climb or descend resolution advisories (RA), ACAS X is a probability-based estimator with a predetermined look-up table for maneuvers. The design greatly simplifies the development, certification and software maintenance aspects of the equipment while cutting the overall number of RAs by an estimated 63%, says the FAA.

The agency has been working on the program for four years and will likely make a final investment decision on the concept in late 2013 or early 2014, pending the results of a flight-test campaign with Honeywell set for August 2013 at the FAA's William J. Hughes Technical Center in Atlantic City, N.J.

The family so far includes four variants: ACAS Xa (active surveillance), Xo (operation specific), Xu (unmanned aircraft system) and Xp (passive surveillance). Initial development is focused on Xa, which will have all the

functionality of TCAS II, and Xo, which will include FAA NextGen capabilities such as closely spaced parallel operations (CSPO). The FAA expects certain procedures, including CSPO, will require Xo equipment for participation.

After a joint U.S. and European RTCA Inc. group develops minimum operational performance standards (MOPS) for Xa and Xo—work that will start in 2014—the agency expects to have an initial operational evaluation in 2018. Once the MOPS are complete, avionics manufacturers can follow the standards to gain technical standard orders (TSO) for the equipment, equivalent to a design and production approval. By 2020, the FAA expects to go live with the technology in tandem with the ADS-B "out" surveillance mandate, though the agency does not expect to issue a mandate for ACAS equipment.

The FAA's chief scientist, Steve Bradford, says the Europeans are sufficiently impressed with the potential for ACAS X that the Single European Sky (Sesar) program "has adjusted its work program" to include it. "They always recognized this as a future program, but they didn't expect the maturity that we have developed," Bradford says.

For the August 2013 flight test, the FAA and its partners will install a Honeywell TCAS II unit with ACAS Xa and Xo software in an FAA Convair 580. Pilots will fly 12 encounter scenarios with surrogate intruder aircraft, including 3-nm in-trail flights and closely spaced parallel approaches. Though the flight test will not use ADS-B as an input,

ACAS Xa and Xo can use the passive surveillance input in a hybrid mode that will reduce the number of transponder interrogations needed for a convergence scenario.

The FAA says it is planning a proof-of-concept flight test of ACAS Xu in

The FAA's family of new collision-avoidance systems will aim to increase safety and decrease avoidance maneuvers.

late 2014. Along with having the options for alternative sensors inputs, including electro-optical and infrared, Xu will provide both vertical and horizontal RA maneuvers to operators.

ACAS Xp, which is much earlier in the planning stages, will provide traffic alerts and a subset of RAs based on ADS-B "out" and "in" capability after 2020. The development could provide general aviation with ADS-B "in" a relatively low-cost safety tool option, assuming avionics makers can bundle the capability with the ADS-B equipment that industry will design to meet the FAA's 2020 mandate for ADS-B "out."

A key reason for a clean-sheet design of TCAS is the amount of work that would be required to retool the legacy platform for NextGen procedures such as CSPO, a practice that will boost capacity at airports, and reduced in-trail distances at altitude, which will increase capacity in the air.

According to a study of 130,000 actual RAs over a multiyear period by the Massachusetts Institute of Technology's Lincoln Laboratory, 84% of the RAs issued by TCAS II avionics in terminal airspace were "unnecessary." The false alarms are issued most frequently when aircraft at instrument flight rules (IFR) cruise altitudes are in the vicinity of general aviation aircraft using visual flight rules cruise altitudes, which by design are separated by only 500 ft. in altitude.

The issues will only worsen as NextGen necessarily puts aircraft in closer proximity, says the FAA. Lincoln Laboratory has demonstrated by simulation that ACAS X will reduce types of RAs seen in today's operations by 57% for business jets, 64% for major air carriers and 69% for regional airlines.

TCAS II, which issues TAs—and RAs, if required—is mandated for commercial airliners and regional jets with more than 30 seats or a maximum takeoff weight exceeding

33,000 lb. However, the FAA says “nearly all” mid- and large-cabin corporate aircraft also have the system, as do “many” light jets and turboprops. Per regulations, turbine-powered passenger aircraft with 10-30 seats must carry TCAS I, a situational awareness aid that issues TAs but no avoidance maneuvers. Several TA systems are available for lighter general aviation aircraft, but none are mandated.

Aside from being a distraction, unnecessary alerts from TCAS II can disrupt air traffic when pilots respond to the alerts, or worse, could eventually prove fatal if pilots become inured to the alerts and ignore them altogether. In the cockpit, an RA is displayed as a vertical speed command by the avionics and often accompanied by an audible “Climb! Climb!” or “Descend! Descend!” command.

The most common unnecessary collision avoidance maneuvers involve safe operations along normal pathways for IFR and VFR traffic.

The alert problem could also affect access to airports. Neil Suchy, the FAA’s ACAS X program manager, says the “first thing” the FAA does for airspace redesign projects is “see where we get the TCAS alerts” and then “design away” from the alerts. The arrival corridor to Runway 8 at Burbank Bob Hope Airport Calif., which overflies the nearby Van Nuys Airport, will likely be changed due to unnecessary RAs that Burbank-bound pilots are receiving based on aircraft in the Van Nuys traffic pattern. Both airports are among the busiest business aviation hubs. Possible modifications include raising the Burbank final approach fix by 250 ft. or creating a “T-route” arrival that bypasses Van Nuys.

TAs and RAs are computed as far out as 40 mi. using a straight-line projection (forward in time) of the own-ship and intruder aircraft motion-based interrogated transponder signals updated once per second. The software checks to see if the point of closest approach (CPA) between the two aircraft will cause a near mid-air collision (NMAC), defined as an incursion into a 500-ft. lateral and ± 100 -ft. vertical disk of

airspace around the own-ship aircraft.

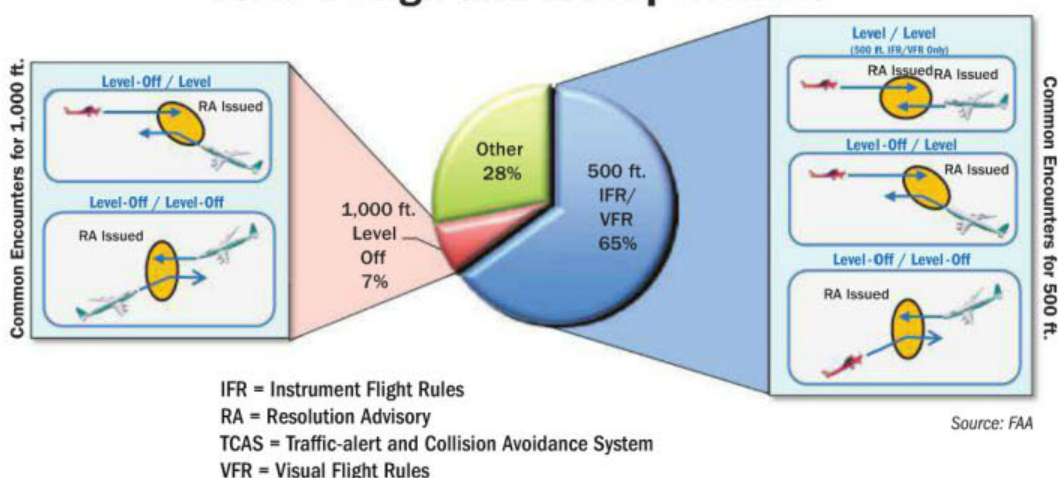
Traffic alerts, accompanied by an audible “Traffic, Traffic,” are issued 20-48 sec. before the forecasted CPA, while RAs are issued 15-35 sec. before CPA. TCAS II issues a direction and target climb or descent rate based on whichever vertical maneuver, a 0.25g upward or downward acceleration, will be least disruptive and still meet that safety buffer criteria at the CPA, factoring in a 5-sec. delay in the pilot’s response between receiving the command and acting. RAs are currently based on vertical maneuvers only, a tactic the FAA will use for ACAS X as well.

The safety benefit from TCAS II is

for going forward. At its core, ACAS X uses a Markov Decision Process (MDP) to decide the best course of action to avoid NMACs. Computationally and computer memory-intensive, MDP, developed in the 1950s, is now possible in an onboard system due to advances in computer hardware driven by the consumer electronic market. The technology is being used in GBSAA systems for unmanned aircraft, with the U.S. Army set to use MDP as its RA source for operators flying Gray Eagle unmanned aircraft at five training sites.

MDP improves on the legacy TCAS in part by taking into account the probability that own-ship aircraft and intruders

TCAS Design and RA Experiences



indisputable. The FAA notes that since the system was mandated in 1993, there have been no U.S. commercial air carrier collisions. Also indisputable, however, is that as many as 84% of RAs occur during safe and normal procedures, such as the Burbank approach.

The FAA investigated whether TCAS could be updated to accommodate NextGen, but ultimately decided on a clean-sheet approach. Part of the difficulty is that TCAS is a collection of rules developed over many years and translated into software (also known as pseudo code). Due to cost, a TCAS II derivative would probably not be feasible for lighter aircraft to gain the safety benefit of TAs and RAs.

“Modifying TCAS II logic will not be sufficient,” says Suchy. “It’s easier to start from scratch.”

An alternative method in use in artificial intelligence, operations research and some ground-based sense and avoid (GBSAA) communities has won the heart of the FAA and is now Plan A

may both move in unanticipated ways in horizontal and vertical directions. While it continuously computes the possible path of the aircraft at 1-sec. update rates considering probabilistic sensor and dynamic models, MDP uses a static “cost matrix” look-up table that is created offline to select the preferred RA. The look-up table has a “penalty” or “reward” for every transition between physical states—the largest penalty is an NMAC; the highest reward is no action.

The reward for the users will be not only substantially fewer unnecessary RAs, but a system that the FAA says will be 56% safer than the most recent TCAS II update (Version 7.1). ☺



To see an animation of the traffic-alert and collision avoidance system at work, check out the

digital edition of *AW&ST* on leading tablets and smartphones, or go to AviationWeek.com/tcas

Close-Up of the G280



The Gulfstream 280 is being hailed as a super-midsize performance champion.

GULFSTREAM AEROSPACE

The latest entry in the 'super midsize' competition is put through its paces

Fred George Dallas

Gulfstream Aerospace soon will begin customer deliveries of its \$24-million G280, a 3,600-nm-range super midsize jet.

Although not new to the category—Gulfstream acquired the Galaxy (nee Israel Aerospace Astra IV) in 2001 and renamed it—the G200's performance was inferior to Bombardier's muscular Challenger 300, which went on to garner nearly 400 sales in the past decade. Nonetheless, G200 operators say their passengers loved the cabin and the aircraft's reliability. Gulfstream, along with Galaxy Aerospace, succeeded in delivering more than 240 aircraft.

Still, to remedy the G200's shortcomings, Gulfstream gave its successor a new wing and empennage and replaced the 6,040-lb.-thrust Pratt & Whitney PW306A engines with a pair of Honeywell HTF7250G turbofans, each rated at 7,624 lb. thrust, giving it the best thrust-to-weight ratio and runway performance in the category. And it boasts a more tanks-full payload, 350 nm more range and better fuel efficiency than its Canadian competitor.

Of equal importance to operators, G280 has more cabin volume than either Challenger 300 or G200, along with a lower cabin altitude and reduced cabin sound levels. Its 120-cu.-ft. aft baggage compartment is the largest in its class and it is now accessible inflight because the G200's aft fuselage fuel tank has been eliminated. G280's cabin has 19 windows—four more than G200.

Up front, there is large, full-service galley and a cockpit jump seat for the flight attendant. The aft lavatory has a vacuum toilet, a first for a super midsize aircraft. And all the way up front, the G280 features a PlaneView flight deck, which will be discussed more fully when we outline the flying characteristics later in this article.

Before taking to the air, it's good to note the regulatory milestones that have been met. G280 has new CAA Israel and FAA Part 25 type certificates, and complies with Federal Aviation Regulations (FAR) Part 25 through Amendment 1-120, plus A122. The European Aviation Safety Agency CS-25 A2 type certification is in the works. The aircraft meets International Civil Aviation Organization Annex 16 and FAR Part 36 Stage 4 noise standards, along with FAR Part 34 fuel venting and exhaust emission requirements.

The green aircraft is assembled at Israel Aerospace Industries (IAI) in Tel Aviv, fitted with a ferry package and flown to Gulfstream's Dallas-Love Field facility for outfitting and painting. The G280's wing—derived from the G550 airfoil with a slightly different twist distribution and new large, wide radius winglets—has more sweep and 495 sq. ft. of area, 34% more than the G200 wing. Similar to G550, design cruise speed is Mach 0.80, up from Mach 0.75 for G200. That yields up to 29 more kt. true air speed (KTAS), enough to shave 30 min. or more off London-New York flight time.

The larger wing, along with the wing center section tank and feeders, also holds 20% more fuel than the G200's, enabling Gulfstream to shrink the forward belly tank and eliminate the 5,515-lb.-capacity, 67-cu.-ft. fuselage tank, replacing it with a 1,130-lb.-capacity aft belly tank. Overall fuel capacity actually is 390 lb. less than the G200's, but the more-efficient wing and new engines make up for the difference.

The G280's T-tail empennage features larger area fin and stabilizers to handle the aircraft's nearly 2-ton weight increase.

The flight-control system of the new aircraft has little in common with that of G200 other than similar pitch-control mechanisms and the stall-protection system. The roll-control system, for example, uses manually actuated ailerons with servo tabs that provide high-fidelity aerodynamic feel. Computer-controlled multi-function spoilers provide most of the muscle needed for roll control. The result is natural feel, abundant roll-control authority and well-harmonized pitch and roll forces at the yoke.

G280 is fitted with a fly-by-wire (FBW) rudder in place of the manually actuated, boost-assisted system on the G200.

In keeping with long-standing Gulfstream design practice, G280 has no leading edge high-lift devices. The trailing edge flaps are electrically controlled and hydraulically actuated.

The aircraft boasts an updated, fully split buss electrical system with increased automatic load shedding compared to G200's hybrid split/parallel buss architecture that shares common emergency and hot battery busses. Aboard G280, there are left and right 28-volt-direct-current (VDC) 400A brushless generators, plus a 28-VDC 400A auxiliary power unit (APU) starter-generator rated for inflight use up to 40,000 ft. at reduced output. Left- and right-side 24 VDC 38AH heated lead-

acid batteries, plus a standby battery, are standard.

The hydraulic system has been updated to provide additional redundancy for the FBW rudder. The left and right sides have both engine-driven and electrically powered hydraulic pumps, similar to Challenger 300. The design provides the necessary power redundancy for the digital FBW rudder.

The G280 has a new brake-by-wire system with an auto-braking function, a first for this class of business aircraft. The auto-braking system has low, medium and high deceleration levels, plus a rejected takeoff off mode for maximum braking.

The ice protection system has been changed significantly. Gone are the G200's pneumatic de-ice boots on the leading edges of the wing and horizontal stabilizer. G280 uses a bleed-air for heated wing anti-ice.

Rockwell Collins Pro Line Fusion avionics provide the backbone of G280's PlaneView cockpit. The main instrument panel features three 15-in. screens with cursor control devices on the left- and right-side ledges and left and right standby multifunction controllers [SMCs] in the glareshield panel. Gulfstream invented the SMCs to provide each pilot with a full-function electronic standby instrument system that doubles as a display and test control box. The 3 X 4-in. full-color LCD screens are in direct, head-up view of each flight crewmember.

Two multifunction control display units in the center console provide a flight management system (FMS), radio tuning and other functions. The throttle quadrant assembly that sends electronic commands to the engine Fadecs has servos that move the throttles in response to auto-throttle commands.

Other standard features include triple VHF comm and dual nav radios, dual distance measuring equipment, dual combined Mode S/Traffic Alert and Collision Avoidance System (TCAS) transceivers, dual FMS with 12-channel wide-area-augmentation/satellite-based-augmentation-system GPS receivers, dual digital air computers and dual solid-state attitude-heading reference systems, along with a single Multiscan weather radar, automatic direction finder receiver, HF transceiver, triple-frequency emergency locator transmitter, radio altimeter, 120-min. cockpit-voice/flight-data recorders and a terrain awareness and warning system (TAWS). A VHF comm radio is data-link capable for air traffic control functions such as Europe's Link 2000.

The passenger seating area is 17 in. longer than the G200's because the fuselage fuel tank has been removed.

Buyers have a choice of interior configurations with standardized floor plans, cabinetry, cabin sidewalls and systems. Eight-, nine- and 10-passenger configurations are available, each having a forward four-seat club section.

About half the buyers opted for an aft section with two facing chairs on the right side with a 6.7-ft.-long, three-place divan on the left. Others selected a four-place conference grouping on the left side of the aft cabin with the three-place divan on the right. The life raft is stored underneath the divan.

All seat pairs fold into berths. The divan may be extended into the aisle to form a 31-in.-wide berth. The aircraft can sleep four on extended flights in fully or near-flat berths.

The cabin management system is designed to use off-the-shelf iPod Touch personal digital assistants (PDA), loaded with a company supplied app, as the remote control. Two iPod Touch PDAs are included with the aircraft. The master seat has an iPod Touch docking station for charging as well as an Iridium satellite phone communications handset.

The cabin audio/visual system offers dual 160-gigabyte media servers that each can store 80-100 high-definition movies. There also are laptop ports for inflight business presentations.

Standard equipment includes a 19-in. forward bulkhead LCD monitor and a proprietary moving map system with flight information, high-resolution satellite imagery, geographic borders and passenger briefing videos.

Belt into the left seat of G280, as we did recently, and it is immediately clear that the Plane-View280 flight deck puts this aircraft on par with the best of Gulfstream's large-cabin aircraft. Brian Dickerson, the company's senior production test pilot, was in the right seat and Bob Wilson, mid-size Gulfstream aircraft experimental test pilot, rode along as safety pilot.

Dickerson explained that G280 is the only aircraft in this class to have both full-authority auto throttles and an auto-braking system. It is also the only super midsize aircraft in current production to offer an optional head-up display and an enhanced vision system, although these were not installed on the demonstrator.

Dickerson and Wilson prepped the aircraft and they had the APU running when we arrived at Gulfstream's ramp at its Dallas-Love Field facility (elev. 487 ft.). Outside, the temperature was 33C/91F; inside the aircraft it was 70F.

Pre-start checks were straightforward, using the standby multifunc-

Gulfstream G280 Specifications	
CHARACTERISTICS	
Wing Loading	80.0 lb./sq.ft.
Power Loading	2.60 lb./lb.f.
Noise (EPNdB)	75.2/89.5/90.1*
Seating	2+8/10
DIMENSIONS (FT./METERS)	
External	
Length	66.8/20.4
Height	21.3/6.5
Span	63.0/19.2
Internal	
Length	25.8/7.9
Height	6.3/1.9
Width (Maximum)	7.2/2.2
Width (Floor)	5.7/1.7
THRUST	
Engines	2 Honeywell HTF7250G
Output/Flat Rating	
OAT°C	7,624 lb. each/ISA+16.7C
Inspection Interval	OC
WEIGHTS (LB./KG)	
Max. Ramp	39,750/18,030
Max. Takeoff	39,600/17,962
Max. Landing	32,700/14,833
Zero Fuel	28,200/12,791
BOW	24,150/10,954
Max. Payload	4,050/1,837
Useful Load	15,600/7,076
Executive Payload	1,600/726
Max. Fuel	14,600/6,623
Payload With Max. Fuel	1,000/454
Fuel With Max. Payload	11,550/5,239
Fuel With Executive Payload	14,000/6,350
LIMITS	
MMO	Mach 0.850
FL/VMO	FL 280/340
PSI	9.2
CLIMB	
Time to FL 370 (min.)	14
FAR Part 25	
OEI rate (fpm/MPM)	846/258
FAR Part 25	
OEI gradient (ft./nm; m/km)	371/61
CEILINGS (FT./METERS)	
Certificated	45,000/13,716
All-Engine Service	44,000/13,411
Engine-Out Service	27,000/8,230
Sea Level Cabin	28,900/8,809
Certification	FAR Part 25 A1-120, 122

* Takeoff/sideline/approach

tion controller to run through stall warning, TCAS and TAWS tests, plus setting the landing field elevation. The FMS performance database was not yet certified, so Wilson computed takeoff data for a 32,000-lb. takeoff weight and flaps 20 deg. He calculated 106 KIAS for V1 takeoff decision speed, 112 KIAS for rotation and 124 KIAS for the V2 OEI (one-engine-inoperative) takeoff safety speed. En route climb speed was 171 KIAS. Using those speeds and opting for a "bleeds off" takeoff, we computed takeoff field distance at 3,725 ft.

Rolling out of the chocks, we found the nosewheel steering and new brake-by-wire system to be smooth and precise.

Once cleared for takeoff on Runway 13R, we advanced the throttles midway and engaged the auto-throttle system. Rpm advanced to 90.6% N1, providing just under 7,400 lb. of thrust on each engine. With a weight-to-thrust ratio of 2.16:1, acceleration was spirited.

Rotation force was moderate and roll force was well harmonized with pitch force. The ailerons and elevator have virtually no perceptible on-center stiction, making the aircraft quite enjoyable to hand fly. In addition, thrust changes cause very little pitch change. Some pilots may not want to relinquish control to the autopilot, but the auto-throttle system is so smooth and precise that there is little reason not to use it.

After takeoff, the pneumatic system automatically switched from APU bleed air to engine bleed air. At that point, we secured the APU.

Following a 250 KIAS/Mach 0.75 speed schedule, the aircraft climbed westward from Dallas-Love to Flight Level (FL) 450 in 21 min., including a 3-min. ATC delay. That is impressive as the outside air temperatures (OAT) were mostly ISA (international standard atmosphere)+15-17C until we climbed above FL300. At FL450, though, OAT cooled off to ISA-5C. Fuel burn for the climb was about 1,000 lb.

We checked cruise performance at Mach 0.80 normal cruise and Mach 0.84 high-speed cruise at FL450 at ISA-5-6C. At a weight of 30,800 lb., fuel burn was 1,510 lb. per hr. (pph) at normal cruise and 1,810 pph at HSC. The flight manual indicates the aircraft's long-range cruise speed at this weight is Mach 0.79 and fuel flow should be about 1,400 pph. At Mach 0.84, it predicts 1,778 pph at that weight and OAT.

The aircraft was buffet-free up to a 40-deg. angle of bank, corresponding to 1.3g. At maximum takeoff weight, the aircraft has 1.2g of buffet margin from Mach 0.75-0.80 at FL450. Buffet margin drops sharply above normal cruise speed.

We descended to 16,000 ft. for airwork southeast of Abilene, Texas, using idle thrust and the variable position speed brakes for drag. The air brakes produce very mild pitch-up when fully extended and just slight airframe rumble that is unlikely to disturb passengers.

When level at low altitude, we flew a couple of steep turns. It is easy to maintain altitude using the primary flight display's flight path marker and airspeed trend vector. Pitch force is moderately heavy, thereby preventing over control. Roll response, with the help of the fly-by-wire roll spoilers, is crisp, but roll effort is moderate, again preventing over control.

Dickerson next demonstrated the low-speed protection system. If the aircraft is slowed to 72% of the angle of attack (AOA) at which the stall warning stick pusher fires, the auto-throttle system engages and power is advanced to prevent the stall. Up to maximum available thrust, the auto-throttle system will not allow angle of attack to exceed 78% of stick-pusher AOA.

We then flew clean, flaps-20 approach and landing configuration stall approaches to stickpusher at weights of 30,150-30,250 lb. For the three configurations, stall warning stickshaker then stall prevention stickpusher, respectively, were triggered at 139 KIAS and 131 KIAS; 113 KIAS and 106 KIAS; and 107 KIAS and 101 KIAS. Aircraft behavior during each of the maneuvers was very benign.

Next, it was off to Abilene's Runway 35R for pattern work, starting with the instrument landing system approach. Wilson pegged Vref at 128 KIAS for the aircraft's estimated 29,600-lb. landing weight, providing a 23% margin over stall. The auto

braking system was set to medium deceleration for demonstration purposes.

We flew the approach at Vref+5 until crossing the fence. The relatively large wing and absence of leading edge/Kreuger flaps provide considerably more ground effect cushioning than in the G200. We floated down the runway for a few hundred extra feet before touching down. The auto-braking action was very smooth and progressive, and the aircraft slowed to moderate taxi speed in about 2,500 ft.

To sample G280's engine-out takeoff performance, Wilson computed speeds of 101 KIAS for V1, 109 KIAS for rotation and 121 KIAS for V2. Just above 101 KIAS, Dickerson retarded the right throttle to

idle, simulating an engine failure. Only light left rudder pressure was needed to control yaw because of the powerful FBW rudder system. But the servo system moved the rudder pedals enough to make it apparent to our feet that the left engine was producing substantially more thrust than the right.

The aircraft was easy to control throughout the simulated OEI approach and landing. We noted that thrust response to throttle movement is very linear and predictable with the HTF7250 turbofans, thus speed was easily controlled. That's a vivid contrast to the throttle response of the G200's PW306As.

After landing, we taxied back to sample the aircraft's auto-braking rejected takeoff feature. During our simulated takeoff roll, Dickerson called "Abort! Abort!" just over 80 KIAS. We snapped the throttles to idle. The ground spoilers fully deployed and the auto braking responded with maximum braking effort. There was the slightest tendency toward triggering the anti-skid system, but the aircraft decelerated smartly to a stop with no loss of directional stability.

Returning to Dallas-Love Field, we easily stopped the aircraft in the first 3,800 ft. of runway.

Conclusions? G280 delivers sporty performance, excellent handling qualities and unsurpassed avionics capabilities in this class of business aircraft. Meanwhile, its range and speed capabilities are on a par with far more expensive large-cabin aircraft. ☺



The Gulfstream 280's cabin is designed with two seating areas, including one with a three-place aft divan.

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Nov. 5-6—University of Westminster Aviation Seminars: "Market Research for Air Transport" and "Practical Techniques and Strategies." Also, Nov. 7-9—"Demand Analysis and Capacity Management: The Air Transport Issues." London. Call +44 (203) 506-6559, fax +44 (207) 915-5410 or see www.westminster.ac.uk/airtransportshort
Nov. 8—Royal Aeronautical Society's Washington Branch Lecture featuring: Tom Burbage and Al Norman of Lockheed Martin. British Embassy, Washington. See www.raeswashington.org
Nov. 12-14—Airports Council International-North America's 2012 Airport Concessions Conference. Sheraton Denver Downtown Hotel. See www.aci-na.org/event/563
Nov. 14-16—Speednews' 17th Annual Regional and Business Aviation Industry Suppliers Conference. Montelucia Resort and Spa, Scottsdale, Ariz. See www.speednews.com/conferences
Nov. 28-29—American Astronautical Association's National Conference. Jet Propulsion Laboratory, Pasadena, Calif. See www.astronautical.org
Dec. 3-5—Worldwide Business Research's Defense Logistics. Marriott Crystal Gateway, Arlington, Va. See www.wbresearch.com/defenselogisticsusa
Dec. 3-5—University of Westminster Aviation Seminar: "Air Transport Business and Management." London. Call +44 (203) 506-6559 or see www.westminster.ac.uk/airtransportshort
Dec. 4-6—Aeromart Toulouse 2012. Center de Congres Pierre Baudis, Toulouse. See www.bciaerospace.com/Toulouse
Dec. 11-13—Middle East Business Aviation. Al Maktoum International Airport, Dubai, United Arab Emirates. Call +44 (208) 846-2740, +971-4603-3300 or see www.meaba.aero+
Jan. 7-10—51st AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition. Gaylord Texan Hotel and Convention, Grapevine, Texas. See www.aiaa.org/asm2013
Jan. 9-10—Fourth Annual China Aerospace Manufacturing Summit. Post Hotel, Harbin. See www.galleonevents.com/2013CAMS/
Jan. 18-20—Wings over Wairarapa Air Show. Hood Aerodrome, Masterton, New Zealand. See www.wings.org.nz/

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Nov. 7-9—JEC Americas Composites Show and Conferences. Boston.
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Dec. 11-13—Middle East Business Aviation. Dubai, United Arab Emirates.

Does Innovation Still Matter?



Markish is a principal at Renaissance Strategic Advisors. He holds degrees in aeronautics and astronautics from MIT and has worked on advanced aircraft design at Boeing Phantom Works.

Innovation has long been integral to aerospace and defense. Generations of engineers and managers have been attracted to an industry synonymous with overcoming daunting technical challenges. Heavier-than-air flight, vertical flight, supersonic flight, spaceflight, precision-guided weapons, radar, sonar, night vision—examples abound of disruptive technologies that have created new capabilities and spawned whole new markets.

And yet, while we all acknowledge the general importance of innovation, A&D executives must decide on their companies' relationships between technology innovation and strategy. The answer is not always obvious.

In defense, companies have to weigh innovation and strategy against the sobering reality of the ending of a decade of unprecedented growth. In the U.S., as deployed operations are drawing down, concern over government debt is compounding uncertainty about how deeply and quickly defense budgets will shrink. Other Western nations face similarly stark budget constraints. Export markets are growing, but so is competition. Suppliers large and small must come to terms with the inevitability of a shrinking demand base.

“Has innovation atrophied? Do we need to reinvent a forgotten art?”

Given this pressure, it would not be surprising to see management teams “hunker down,” minimizing costs, limiting discretionary spending and protecting margins. That might seem attractive—even necessary—in the near term, and placate nervous investors. But such an approach also runs the risk of eroding a company's long-term competitiveness—and may even threaten its viability. A less intuitive approach would be to invest in technology innovation as a competitive tool, creating differentiation and securing favorable long-term positioning for the company in an eventual market recovery.

While the commercial aerospace sector is today much healthier—businesses are poised to convert record backlogs into record cash flows—its companies face a similar decision about whether to reinvest some of those profits in innovation. While the outlook is positive now, the growth ramp is clouded by global financial and geopolitical uncertainty. And the field is becoming markedly more crowded with

new entrants. When orders moderate, a competitive advantage built on technology differentiation may become not just an asset, but a necessity.

If a management team agrees that innovation is worth the investment as a core component of strategy, then it must decide how to deploy resources to maximum effect. After all, money spent on innovation in A&D has lately been the subject of concern. Many of today's most prominent programs—whether large commercial aircraft, fifth-generation fighters, armored vehicles or destroyers—can be viewed as incremental improvements on established approaches. Worse, these programs too often are known as much for their cost and schedule overruns as for the technological boundaries they expand. Has innovation atrophied? Do we need to reinvent a forgotten art?

One view holds that the setbacks we see in current programs do not represent the withering of innovation. Rather, they result from the naturally higher development risk that attends the design of ever more capable systems of increasingly greater complexity. Adherents to this view argue that in addition to massively improved systems that build on established design principles, the A&D industry continues to develop game-changing capabilities—from modular, lower-cost ships to persistent-surveillance UAVs to missile defense and electromagnetic weapons. Such innovation—whether incremental or revolutionary—will continue to absorb significant resources, entail substantial risk and require incumbent industry specialists with the size and structure to bring them to fruition.

A different view holds that innovation has not atrophied, but has migrated and changed. Whereas the traditional focus has been on “higher, faster, farther,” the core of innovation has shifted to “better, quicker, cheaper.” The most dynamic innovations today revolve less around meeting demanding performance requirements and more around improving the delivery of solutions to customers.

It is this paradigm that is most likely today to produce “disruptive” innovations. Witness the adaptations of surveillance UAVs into hunter-killer special-ops platforms, business-aviation turboprops into versatile signals intelligence platforms and commercially derived data-mining software into critical indispensable tools.

The A&D industry is diverse enough to support a range of approaches across different market segments. But as management teams consider what innovation means to their business models, they must remember that technology innovation can be a differentiator worth the investment, whether they are going into an upturn or a downturn. ☐



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