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Lockheed Martin is inching closer to solving some of the technical challenges of the F-35 during development as the Pentagon's incoming program director says relations with the company are "the worst I've ever seen."



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AIR TRANSPORT

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- 40** Authorities in Asia have failed to address the need for bigger airports fueled by passenger growth
- 42** Repeated delays in beginning work on new Beijing airport driving the city toward a capacity crunch

INTERNATIONAL AIR TRANSPORT

COVER STORIES

A Boeing 747-400 takes off from Sydney Kingsford Smith Airport, one of many Asia-Pacific hubs where capacity constraints could be a major challenge to air traffic growth, as discussed in a special report beginning on page 40. Demand for flights is forecast to continue to rise in Southeast Asia, but airports in Singapore, Bangkok, Manila and Jakarta face congestion issues. In both Beijing and Sydney, new airports have been proposed to relieve the pressure on the primary facilities, but progress on these plans has been slow. Sydney airport photo.



- 36** Investors are notably uninspired and European governments lukewarm to a merger of EADS and BAE Systems.

- 31** U.S. embarking on development of a new generation of fighter engines that is expected to produce a fundamental advance in propulsion.

- 28** China's unveiling of a second stealthy fighter follows the same pattern as the revelation of the J-20 at the end of 2010.



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FUTURE POWER

💬 **Pratt & Whitney beat out Rolls-Royce** for the U.S. Air Force Research Laboratory's follow-on Adaptive Engine Technology Development (AETD) program, which is designed to help determine what may power the next fighters for the Air Force and Navy. See Senior Technology Editor Graham Warwick's take on Pratt's win in our Ares blog at: tinyurl.com/ccezskt



SPACECHAT

💬 **European Editor Amy Svitak** made the best of the 5 min. she spent with SpaceX's president, Gwynne Shotwell, with some pointed questions. Read about their exchange on our OnSpace blog at: tinyurl.com/c5e3tt9

CUTTING IT CLOSE

💬 **Will Bombardier** make its ambitious target of year-end for the first

flight of its new CSeries jet? Will it deliver the first aircraft by the end of 2013 (page 14)? Our Things With Wings delves into the ambitious development schedule at: tinyurl.com/8ojxsd9

2013 LAURELS

✨ **Nominations are open** for Aviation Week's 56th Laureate Awards, our annual recognition of extraordinary accomplishments by individuals and teams in the aerospace, defense and

airline industries. To see a list of categories and make a nomination, go to:

AviationWeek.com/events/current/lau/nominate.htm

WHY WAIT?

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From the Web

Comments from readers
on **AviationWeek.com**

On the Ares blog, DTI Editor Bill Sweetman notes that short takeoff and vertical landing (Stovl) has been one of two driving requirements behind Lockheed Martin's Joint Strike Fighter design, the other being stealth. He lists several constraints dictated by the design and says: "If you ever wondered what a JSF might look without those constraints, we now have an example... Unfortunately, it's Chinese," apparently designated J-31.



andre—sh says:

Looks good. Much better than their J-20. The less the Chinese invent, the better the results. Congratulations to them.

Hardcore notes:

The Soviets were also accused of being copycats. The basic configuration is a copy of a proven type for sure, (but they could have chosen a better role model; the PAK FA is a more advanced design). Apart from that I expect it to be Chinese under the skin. Also, it will be cheaper and fly better than the JSF.

LHC observes:

The center bay looks huge, perhaps to internally carry anti-ship missiles?

Geoghan posts:

It looks longer than an F-35, perhaps in the MiG-35 class? Around 56 ft. long with a 39-ft. span? The wing does not seem quite as large as the F-35C. If overall it is slightly larger than the F-35C, could the empty weight be around 35,000 lb.? This of course would impact engine considerations [which are posted].

Rocket27 asks:

Does the twin nose gear mean the aircraft could be catapult-launched from China's future carriers, unlike the bigger J-20?



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

Feedback

PAST, PRESENT, FUTURE INNOVATORS

Your Innovation feature is just a facet of one of the best-written and most informative issues in recent times (AW&ST Sept. 3/10, p. 56). I also enjoyed "Above All, A Pilot" (p. 32) on Neil Armstrong's path to the Moon. Outstanding!

Augustine R. Letto
ALBUQUERQUE, N.M.

COVER CALL

It was disrespectful to opt not to feature Neil Armstrong on the cover. You correctly gave Scott Crossfield pride of place when he died. Only a few aviation and space pioneers are cover-worthy. Armstrong was certainly one of them.

Lawrence Maduras
ELK GROVE, CALIF.

ONE IN COUNTLESS BILLIONS

When Neil Armstrong commanded Apollo 11 in 1969, 3.5 billion people were alive. It is estimated that more than 100 billion humans had lived and died prior to 1969. The odds of being born and being the first human to set foot on the surface of a body beyond Earth were about 1 in 105 billion when Armstrong took his small step.

The odds of finding another "First Man" with his grace, humility, dignity and common decency—virtually zero. May his spirit soar forever.

Daniel Jenkins
SANTA ROSA, CALIF.

ARMSTRONG, PRE-NASA

James R. Asker's comprehensive tribute to Neil Armstrong was exceptional. I wanted to further comment on his contribution to the X-20 Dyna-Soar program, plus his excellent career timing.

While assigned to that USAF/Boeing program, Armstrong developed and flew a complex launch/abort maneuver for the proposed X-20/Titan IIIC. Based on his diagrams, the Cape Canaveral launch pad and 10,400-ft. runway were replicated with markers on Rogers Dry Lake at Edwards AFB, Calif. The flight profile used a modified delta-wing Douglas F5D-1 Skylancer that approached the launch pad marker at high speed, and pulled into a vertical 3.5g climb simulating an X-20/Titan IIIC ascent. Replicating an abort/separation of the X-20 at approximately 9,500 ft., an inverted pullover was executed with reduced power, reaching 15,000 ft. With the

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**

Letters should be shorter than 200 words, and you must give a genuine identification, address and daytime telephone number. We will not print anonymous letters, but names will be withheld. We reserve the right to edit letters.

F5D-1 level inverted, the aircraft was rolled upright (Immelman maneuver).

In idle power with landing gear down and using speed brakes, the F5D-1 in a low-lift/drag-ratio landing approach simulated an unpowered X-20.

In September 1962, Armstrong left the Dyna-Soar program to become an astronaut. His career timing was impeccable. The X-20 was canceled in December 1963 and the rest is history.

Erik Simonsen
CHINO HILLS, CALIF.

REARING RISK TAKERS

In response to the editorial "To Succeed, First Dare to Fail" (AW&ST Aug. 27, p. 54), it should be noted that in the last several decades, parents have taught children to be more risk averse, and those children have grown up to be decision-makers. There are still risk takers, because what seems risky to one person is not to another with a better background. The two outcomes of risk—elapsed time and money spent—have varied in relative importance throughout aviation's history, depending on mainly uncontrollable external factors. Training in risk-taking happens mostly when doing stress analysis and project management. Reliability analysts and accountants see the results.

Many aviation industry conferences/courses focus on risk management, but ignore the prerequisites of understanding history and conducting risk analysis. The record of past programs is sometimes buried so deep as to discourage research, but there are now too few of them in recent history to provide sufficient perspective to the casual observer. A technology advancement effort like the X-51 program usually requires successful completion; maybe such efforts should be regarded as continuous, with continuous funding—novel but doable; then we would not be so frequently hamstrung by budget constraints.

Doug Culy
TEMPE, ARIZ.

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Cecilia Leung



Robert Ferrante



James B. Armor

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Marvin R. Sambur (see photo) has been appointed president and CEO of Bethesda, Md.-based *Burdeshaw Associates*, succeeding U.S. Army Gen. (ret.) **William W. Hartzog**, who will retire but remain a member of the board. Sambur has been president and CEO of ITT Defense and assistant Air Force secretary for acquisition.

Kim Graven-Nielsen has been promoted to CEO from adviser and vice chairman of *Nordic Aviation Capital*, Billund, Denmark. **Soren Overgaard** is the new CFO, following a tenure as CFO of Damco Europe and senior positions at the AP Moller Group.

Peter Bols (see photo) has been named CFO of Paris-based *MBDA*, succeeding **Julian Whitehead**, who has moved to EADS Cassidian. Bols was CFO of the AirTanker consortium at EADS.

Conrad Theisen has been promoted to avionics sales manager from senior project manager and **Mike Warren** to maintenance sales manager from completions parts buyer at *Elliott Aviation*, Moline, Ill.

Kurt Edwards has been appointed director general of the Washington-based *National Business Aviation Association*. He has held positions in the FAA's international affairs and environmental offices.

Teri G. Marconi (see photo) has joined *Northrop Grumman*, Linthicum, Md., as sector VP and general manager of the Naval and Marine Systems Div. within the Electronic Systems sector. She was VP-business development and has been VP of combat avionics systems.

Orhan Abbas has been appointed New York-based senior VP-commercial operations for the Americas for *Emirates*. He was VP for India and Nepal.

Dirk Erat (see photo) is the new head of communications at *EADS Cassidian*, Unterschleissheim, Germany. He was head of company communications at Porsche and has held several roles at Siemens.

Steve Ridgway, CEO of *Virgin Atlantic Airways*, plans to retire in the spring of 2013, following a 23-year tenure, including nine years as CEO.

Cecilia Leung (see photo) has been named general manager of corporate

communications at Hong Kong-based *Cathay Pacific Airways*. She was general manager of inflight services and general manager-international affairs at Dragonair.

Teri Bristol and **Maurice Georges** have been named to the executive committee of the Amsterdam-based *Civil Air Navigation Organization*. Bristol, chief operating officer at FAA-ATO, was co-opted as a member at large, following the retirement of **Rick Ducharme**.

Robert Ferrante (see photo) has been tapped to become VP of Microwave Solutions of the Electronics Group of *Crane Aerospace & Electronics*, Redmond, Wash. He was VP and general manager for ITT Exelis Airborne Electronic Attack Div.

Davert Leong has been appointed electrical engineer in production, while **David Casey** is the new lead embedded-software engineer and **Doyle Sisson**

project manager at *International Communications Group*, Newport News, Va. **Debbie Glass** has been added as a technical writer. Leong has been a lab technician for the U.S. Department of Veteran Affairs and Casey comes from a career with Rockwell Collins. Sisson was final assembly manager for the Boeing Business Jet and has been program manager at Raytheon, AIS and Laird Technologies. Glass worked for Rockwell International and United Space Alliance at the Kennedy Space Center.

Scott McKenzie has been named avionics technical representative for *Duncan Aviation*, Lincoln, Neb. He was an avionics line crew leader.

USAF Brig. Gen. John K. McMullen has been appointed deputy chief of staff for operations for Allied Air Command at Headquarters Allied Air Command, Allied Command Operations (NATO), Ramstein AB, Germany. He has been commander of the 325th Fighter Wing of Air Education and Training Command, Tyndall AFB, Fla.

USNRear Adm. (lower half) Thomas L. Brown, 2nd, has been named director of military support at the National Geospatial-Intelligence Agency, Springfield, Va. He has been commander of Special Operations Command within U.S. Southern Command, Homestead Air Reserve Base, Fla.

HONORS AND ELECTIONS

James B. Armor (see photo) has been selected by the *American Institute of Aeronautics and Astronautics* to receive the 2012 AIAA von Braun Award for Excellence in Space Program management. He is being honored for his leadership as a U.S. Air Force officer, GPS program manager, leader of signals intelligence systems and National Security Space architect.

C. D. "Dan" Mote, Jr., has been nominated to become president of the Washington-based *National Academy of Engineering* for a six-year term. He is a past president and regents professor of the University of Maryland.

Linda Celestino of Oman Air is the new president of New York-based *Apex*. Other new board members are: VP, **Alfy Veretto** of Virgin America; treasurer, **Joan Filippini** of Paramount Studios; **Ingo Wuggetzer** of Airbus; and **Ashley Woodall** of JetBlue Airways.

Malini Krishnan, a senior software quality engineer at *Rockwell Collins* in Hyderabad, India, has been named Rockwell Collins Volunteer for 2012. Her work includes activities to assist children in need and development of a prototype Android application that combines local emergency response systems. ☺



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AW&ST/S&P Market Indices

(as of 9/19/2012)

PERCENT CHANGE



Weekly Market Performance

Closing Prices as of September 19, 2012

Company Name	Current Week	Previous Week	Fwd. P/E	Tot. Ret. 3 Yr.	Tot. Ret. 1 Yr.
AIR TRANSPORT					
AAR Corp.	17.17	16.78	10.1	-4.7	-10.0 ▼
ACE Aviation Holdings	3.07	2.85	-2.3	166.8	13.7 ▲
AerCap Holdings N.V.	12.53	13.00	5.9	40.2	20.8 ▲
Air Berlin	2.06	2.19	-1.6	-59.0	-42.8 ▼
Air Canada	1.26	1.15	6.8	-29.3	-27.6 ▼
Air France - KLM	5.98	6.04	-3.2	-62.2	-20.3 ▼
Alaska Air Group	34.51	34.72	6.5	161.0	19.1 ▲
All Nippon Airways Co Ltd.	2.30	2.34	13.9	-32.8	-27.0 ▼
Allegiant Travel Co.	65.21	66.15		55.1	42.2 ▲
Asiana Airlines Inc.	6.32	6.34	6.9	76.7	-21.1 ▼
Atlas Air Worldwide Holdings	56.50	56.98	10.2	76.6	30.1 ▲
BBA Aviation plc	3.27	3.24	11.3	44.3	22.3 ▲
B/E Aerospace Inc.	41.96	39.84	13.9	111.8	25.3 ▲
CAE Inc.	10.89	10.51	13.2	23.4	6.1 ▲
Cathay Pacific Airways	1.67	1.63	20.5	11.8	2.0 ▲
China Southern Airlines	21.70	21.64		42.4	-13.9 ▼
Copa Holdings SA	85.25	82.78	10.6	99.8	23.8 ▲
Delta Air Lines Inc.	9.37	9.50	3.7	4.6	11.9 ▲
Deutsche Lufthansa AG	14.19	13.83	15.9	-4.4	8.1 ▲
easyJet plc	9.30	8.96	10.0	53.9	83.9 ▲
FedEx Corp.	86.90	89.08	13.2	16.1	16.3 ▲
GOL SA	5.56	5.36		-43.6	-18.5 ▼
Hawaiian Holdings Inc.	5.83	5.86	5.3	-30.8	29.8 ▲
Heico Corp.	38.25	36.64	21.8	84.1	2.7 ▲
Jet Airways (India) Ltd.	6.67	6.40	-8.9	13.0	28.2 ▲
JetBlue Airways	5.09	5.09	8.6	-21.2	17.0 ▲
Korean Air Lines Co. Ltd.	44.40	44.33	9.9	4.7	-6.2 ▼
Lan Airlines SA	25.33	24.66	23.6	104.4	-2.6 ▼
Qantas Airways Ltd.	1.30	1.30	11.6	-54.1	-16.1 ▼
Republic Airways Holdings Inc.	4.90	4.84	5.0	-52.2	73.1 ▲
Ryanair Holdings ADS	32.60	32.01	75.2	15.9	30.7 ▲
Singapore Airlines Ltd.	8.81	8.53	24.4	-9.5	-0.1 ▼
Skywest Inc.	10.75	9.85	8.6	-37.9	-11.2 ▼
Spirit Airlines Inc.	17.19	19.77	8.8		43.8 ▲
Southwest Airlines	9.06	9.18	10.3	-5.8	7.1 ▲
TransDigm Group Inc.	143.05	142.95	18.8	250.5	58.6 ▲
United Continental Holdings Inc.	20.69	20.31	5.4	142.8	-0.4 ▼
United Parcel Service Inc.	74.27	73.64	15.4	38.1	15.5 ▲
US Airways Group	10.97	11.82	3.9	120.3	83.8 ▲
WestJet Airlines Ltd.	17.71	17.87	10.3	60.3	27.7 ▲
Zodiac Aerospace SA	104.21	100.65	13.3	227.8	39.2 ▲

COMMENTARY

Using More Seats For More Orders

Airbus and Boeing may have sought to fortify their dominance of the narrowbody jet market by offering reengineered versions of the A320 and 737, but **Bombardier** is proving to be a scrappy challenger. The Canadian airframer's recent move to squeeze another 11 seats into its new CSeries jet—for a total of 160—appears to have increased the aircraft's appeal.

The CS300, the larger of the two CSeries variants, received a high-profile endorsement last week as a viable airframe for low-cost carriers. Spanish airline **Vueling**, which plans to order at least 60 aircraft in the next few months, had initially limited its search to Airbus and Boeing. But the low-cost carrier says it is now seriously considering the larger-size CS300. "The CSeries will be the new narrowbody in town for a long time," Vueling CEO Alex Cruz said in an address to the World Low Fare Airline Congress in London. He adds that the Canadian government's eagerness to help finance CSeries sales is "quite an asset."

An order from Vueling would follow something of an upset pulled off by Bombardier earlier this year. In June, **Air Baltic** was close to choosing between the reengineered A320NEO and 737 MAX. But the Latvian airline, which is looking to replace old 737s, changed its mind after receiving a last-minute proposal from Bombardier and signed a letter of intent to acquire 10 CS300s. Air Baltic CEO Martin Gauss says Airbus and Boeing could not match the Bombardier offer. Other airlines considering the CSeries include **AirAsia** and **EasyJet**.

When CSeries development was launched in 2008, Bombardier executives maintained that the 110-149-seater would not compete with the A320 or 737. In moving up to offer 160 seats, Bombardier is dropping any pretense that it is not competing directly against Airbus and Boeing. The additional 11 seats would not require a stretch of the aircraft, but would be squeezed in by installing slimmer seats with a 28-in. pitch and reducing the number of lavatories.

But is a 160-seat product a game-changer? Teal Group analyst Richard Aboulafia questions how much a higher-capacity jet will help Bombardier win much-needed marquee orders for the CSeries. He notes that the Air Baltic order has yet to be finalized, and questions whether other airlines that have publicly praised—but not ordered—the CSeries are simply trying to squeeze better deals out of Airbus or Boeing. "It's a good product, and they've never had a problem with customer interest," Aboulafia says. "They've got a severe problem, however, with closing deals."

Indeed, while the A320NEO has attracted more than 1,400 firm orders and the 737 MAX is at 664, the CSeries has notched just 138 in four years. Meanwhile, Bombardier's goal of delivering the first jet by the end of next year appears to be ambitious, given that major parts for the first flight-test aircraft won't arrive at the final assembly line in Quebec until late this month. Crunch time has arrived. ☹

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

DEFENSE

Tanker Estimates in Flux

Boeing is exhausting its management reserve on the U.S. Air Force KC-46A aerial refueler program faster than expected, and the program management team is investigating the cause as it assembles a revised cost estimate for Congress, says a senior Air Force official. Program overseers use management reserve funding to solve problems that typically crop up during development. Boeing officials say they expedited risk-reduction efforts on the program. "We have brought forward the allocation of management reserve largely in order to expedite risk mitigation opportunities, such as system integration laboratories," says Boeing spokesman Damien Mills. However, "the total management reserve budget remains unchanged." Boeing won the fixed-price, incentive-fee contract 18 months ago, and government auditors have previously estimated the cost for development completion to be \$5.3 billion, above the government's negotiated ceiling price of \$4.9 billion.

Arrow 3 Launch Postponed

The first end-to-end test of Israel's Arrow air defense system carrying the new advanced-performance Arrow 3 interceptor was canceled Sept. 16, during preflight preparations "a few days" before the actual launch date. Due to the Jewish holidays in September, the launch date will not be rescheduled until October when industry and government officials return to work.

Heron TP Flying

The Israeli air force has resumed operations with its Israel Aerospace Industries Heron TP unmanned aerial vehicle after lifting a grounding order imposed following a Jan. 29 crash. The decision came after a successful test, clearing the aircraft for safe operation. The aircraft, also known as Eitan, is the largest unmanned system in air force inventory. A combined investigation by IAF and IAI concluded the accident was caused by a wing structural failure, probably due to a manufacturing process. The new conclusion counters initial beliefs that the UAV crashed after exceeding the limitations of its flight envelope due to excessive payload or pilot error.

Third Team Lucky?

Industry's game of musical chairs



Boeing Links U.S. and Brazilian Simulator Displays

Using cockpit simulators for a Brazilian air force F-5 in Porto Alegre and an F/A-18E/F at its military aircraft headquarters in St. Louis, Boeing has demonstrated how it can link a network of simulators across distances as great as 5,000 mi.

Boeing has been strengthening its manufacturing and technology ties with Brazil for several years in a number of areas, but nowhere more so than in its drive to demonstrate advanced systems capabilities and win the Brazilian air force's F-2X fighter competition.

"Both participants fired weapons at simulated threats and saw the results," F/A-18 mission systems leader Jerry Berg says of the Aug. 29 test, which lasted 25 min. Berg says pilots for both aircraft could see each other and fly together in virtual Brazilian airspace during the exercise.

Boeing has included Elbit Systems on its F/A-18 team and used the Israeli company's large-area display and low-profile head-up display as elements in an advanced cockpit system in the test. Boeing also is using the Elbit displays for its F-15SE, which the company has entered in South Korea's F-X multi-role fighter competition. An Elbit subsidiary, AEL Systemas, is investing in the advanced cockpit avionics that Boeing is using in the F-X2 competition.

Boeing says the test demonstrated how its advanced cockpit systems can provide more realistic training using network linkages. It "holds the promise of future networking and cockpit technology collaboration," says John Keeven, manager of the F/A-18 advanced capabilities laboratory.

around the Pentagon's restaged competitions for presidential-transport and combat-rescue helicopters may have reached a conclusion, with AgustaWestland teaming with Northrop Grumman to once more offer the AW101 for both requirements. Lockheed Martin won the original U.S. Navy VXX presidential helicopter contest with a version of the AW101, but the program was canceled in 2009 following massive budget overruns. Lockheed lost the U.S. Air Force's CSAR-X combat search-and-rescue contest to the Boeing HH-47 Chinook, but that too was terminated in 2009. Lockheed subsequently teamed with

VXX and CSAR-X loser Sikorsky to offer its H-92 helicopter for the presidential helicopter and UH-60M for the restarted Combat Rescue Helicopter program. AgustaWestland and Boeing, meanwhile, agreed in June 2010 to offer the AW101 for VXX. But in the absence of a formal requirement, the agreement was terminated in April, and Boeing says it could offer either the CH-47 or Bell Boeing V-22 tiltrotor for VXX. Now Northrop Grumman has agreed to offer U.S.-built AW101s for both helicopter programs. The secret to making sure the presidential helicopter escapes cancellation a second time will be set-

ting a ceiling on requirements early, says Scott Winship, vice president of advanced programs for Northrop Grumman Aerospace Systems.

Indian Acquisition

The Indian air force (IAF) aims to spend more than \$30 billion over the next 10 years to modernize its forces, according to its deputy chief, Air Marshal R.K. Sharma. Force structure plans call for reaching 42 squadrons by 2022, up from 34. The government has introduced several measures to leverage capital acquisitions and develop the country's defense industry, including relaxing offset guidelines. Nevertheless, India remains plagued by corruption and poor management of some defense acquisitions, as well as complaints by Western contractors about offset requirements.

Agni-IV Tested

India successfully conducted a development test of its nuclear-capable, surface-to-surface Agni-IV missile on Sept. 19 from a military base in the eastern state of Odisha. The missile will be introduced into service next year after one more planned trial, a defense ministry official says. After climbing to an altitude of more than 800 km (500 mi.), it reportedly reentered the atmosphere and reached the pre-defined target in the Indian Ocean in about 20 min.

AIR TRANSPORT

Africa's First 777F

Ethiopian Airlines added another "first" to its Boeing list with its acceptance of a 777 Freighter that it is leasing from Gecas. Last month, Ethiopian became the first African carrier to take delivery of a 787 and in 2010, it was first in Africa to receive a 777-200LR. Meanwhile, Boeing says it formally signed an order with Dublin-based Avolon leasing for 10 737-8s, five 737-9s and 10 737-800s that was initiated at the Farnborough air show. Avolon's order raises Boeing's total 737 MAX count to 664 aircraft and the net total for 737s this year to 696.

First Step

Air Canada has started recruiting 50 pilots and 150 flight attendants for a wholly-owned low-cost subsidiary scheduled to launch next year. While Air Canada is withholding many of the details on its new subsidiary until



Nearing Journey's End

NASA's space shuttle Endeavour landed atop its Boeing 747 carrier aircraft at Edwards AFB, Calif., just before 1 p.m. local time, marking the penultimate stop of its final journey into retirement. The shuttle, which was the last to be built, completed 25 missions and spent 299 days in orbit.

Endeavour will be displayed at the California Science Center following its delivery by the 747 to Los Angeles International Airport (LAX) on Sept. 21. The final journey from NASA's Dryden Flight Research Facility at Edwards was scheduled to include flyovers of San Francisco, Sacramento, the southern California coastline and various sections of the Los Angeles basin and surrounding cities.

After its arrival at LAX, Endeavour will be removed from the 747 and spend a few weeks at a United Airlines hangar undergoing preparations for transport and display. The shuttle then will travel through the streets of Inglewood and Los Angeles on a 12-mi. trip to the science center, arriving in the evening of Oct. 13. The shuttle will be on display from the end of October in the science center's Samuel Oschin Space Shuttle Endeavour Display Pavilion.

Although Endeavour has been retired, elements of its propulsion system are destined to fly into space again as part of NASA's Space Launch System (SLS). The shuttle has become "an organ donor" to the SLS for which Boeing is planning to use a modified Delta 4 upper stage for the first two missions. SLS will launch the Lockheed-built Orion Multi-Purpose Crew Vehicle to fly around the Moon in 2017 and 2021. Parts from Endeavour earmarked for the SLS include some of the vehicle's 17-in. cryogenic relief valves used in the space shuttle main engine and main engine gimbals.

it releases its third-quarter results on Nov. 8, the carrier has told its unions the division will launch with six Airbus A319s and six Boeing 767s, and grow to 30 A319s and 20 767s in 2015.

Inflight Systems Installed

Boeing says it is looking across the industry to develop systems installations for inflight cell phone, Wi-Fi connectivity and Internet access on 747-8s and 777s by the end of 2013. The 737 may receive additional connectivity systems; it already includes wiring positions for connectivity systems. As part of its standard catalog, the 787 offers a post-delivery retrofit of systems for cell phones and Wi-Fi connectivity.

SPACE

SpaceX Launch to ISS Slated

Space Exploration Technologies Inc. (SpaceX) is targeting Oct. 7 as the date for its first commercial cargo mission

to the International Space Station with its Falcon 9 launch vehicle and Dragon cargo carrier. Liftoff is scheduled for 8:34 p.m. EDT from Cape Canaveral. The first of 12 flights under SpaceX's \$1.6 billion Commercial Resupply Services contract with NASA, the mission will deliver about 1,000 lb. of freight to the ISS, most of it scientific equipment and supplies. The vehicle is scheduled to return in late October.

Corrections: An item in *The World* in the Sept. 17 issue (page 18) incorrectly stated the speed at which NASA's Mars Curiosity rover will travel. It will travel as much as 40 meters (130 ft.) per Martian sol.

A business aviation-related article in the Sept. 17 issue (page 62) incorrectly identified which Bombardier Global model will offer a 7,300-nm range at Mach 0.85 cruise when it becomes available in 2016. It is the Global 7000.

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Customer Success Is Our Mission



By Graham Warwick

Senior Editor-Technology
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COMMENTARY

Surface Detail

Changes to aircraft skins could bring big benefits

Mention aircraft structures and advanced materials and it brings to mind the heavy bones—the ribs, spars, planks and beams that make up the skeleton. But developments affecting the outer layers of the aircraft's skin—just millimeters deep, microns even—promise to have a huge impact on weight, cost and efficiency. The skin of an aircraft has taken on new importance with the move to composite airframes, which brings the need to add lightning-strike protection to the non-conductive carbon-fiber materials used in the place of aluminum. Today, this is achieved by adding a layer of conductive expanded-metal foil on top of the composites, but this adds weight, production steps and cost.

As an alternative, U.S.-based Lord Corp. has developed a conductive epoxy coating with half the weight of expanded copper foil and simplified manufacturing, but similar lightning-strike protection performance. Developed from a technology used to remove heat from microchips and displays, UltraConductive is now in evaluation by aircraft manufacturers, with flight tests planned for next year, says Seth Carruthers, lead staff engineer with Lord Chemical Engineering.

Available as an adhesive film or spray-on coating, UltraConductive is applied to the tool before layup of the carbon-fiber prepreg, then co-cured with the composite part in an autoclave. The raw material becomes conductive during curing. When heated, conductive particles suspended in the epoxy polymer "self-assemble" so they are touching each other. "The biggest trick is to get the polymer matrix out of the way, to stop it [from] coating the particles and preventing them [from] forming a three-dimensional mesh," he says.

Compared with expanded copper foil at 0.064 lb./sq. ft., the film weighs 0.039 lb./sq. ft. and the spray coating 0.029 lb./sq. ft.—savings of up to 55%. The improved surface finish compared with expanded-metal foil also provides indirect savings in the weight of prim-

GUY NORRIS/AVIATION WEEK



er and paint required. Lord calculates total weight savings of around 390 lb. for a narrowbody and almost 1,175 lb. for a widebody airliner.

There are also touch-labor reductions during fabrication. Today, to ensure that energy from a lightning strike is safely conducted around the airframe, composite panels must be sanded to expose the copper foil and then joined electrically. "[UltraConductive] is conductive in all axes. You don't need to sand the edges, you just apply the contact patch or joining strip. There are a lot of weight savings, and ease of application," says Carruthers.

Designed to meet the Zone 2A lightning-strike requirements applied to most of an aircraft's wing and fuselage, UltraConductive is intended to match the performance of metal foils. "We are not trying to outperform foils;

it is designed for weight savings," he says. "We have tried to match all the secondary properties, to make sure it is equivalent or better and will last the life of the aircraft." UltraConductive also could be used in addition to metal foil, to provide added redundancy over critical areas such as fuel tanks.

Lord is moving into production of the new material. "We are scaling up to a pilot level this year," Carruthers says. "There are several trials this year, to iron out the certification procedures." Approval remains a hurdle to early adoption, making it unlikely that aircraft already in production will make the switch from metal foil to UltraConductive. "It could be introduced during a block change or on a new platform," he says.

Carruthers notes that Lord has opted against using nanoparticles, to avoid health concerns and keep costs down. But several researchers are looking at using nanomaterials to make composites conductive. Germany's Fraunhofer Institute, for example,

Boeing uses expanded metal foil to protect the 787's carbon-fiber composite airframe from lightning-strike damage, but this adds weight to the aircraft.

is looking at integrating nanomaterials into the composite wing skin to improve lightning-strike protection and to heat the wing for de- and anti-icing.

In addition, a hydrophobic or water-repellent coating, created by blending additives into the paint topcoat, could be used to prevent melt water from the heated leading edge from refreezing on the lower wing and forming runback ice. Creating coatings that will remain stable for several years is the challenge, Fraunhofer states.

The research institute also is looking at using shape-memory materials for wing skins that change their volume when an electrical current is applied, breaking loose any ice accumulation, and predicts energy savings of up to 80% over conventional heating methods. Additionally, Fraunhofer is developing a method of impressing microscopic grooves into the aircraft's paint during application to reduce skin-friction drag. ☼



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

COMMENTARY

The Global Company

Continental economic, political complications lie ahead for European aerospace behemoth

If the proposed EADS/BAE Systems linkup becomes a reality, the biggest aerospace and defense group in the world will be European. Although it would signify the culmination of a long consolidation process, such a milestone will be startling. Establishing a dual civil-military group significantly bigger than Boeing is no easy undertaking and should be assessed beyond the numbers alone: U.S. analysts tend to forget that Europe, despite solid achievements in the past 50 years, remains a complex mosaic of 27 EU members and additional nations such as Switzerland.

Although these states share common long-term goals, creating much more than a single market, multiple difficulties are slowing the unification process much more than pro-Europe opinion leaders expected. Moreover, all EU members face divergent economic problems, as shown by the so-called Euroland's dire fiscal straits. Left-wing and conservative policies frequently cannot be reconciled, and the long-lasting economic downturn—which is pummeling the Western world, not just Europe—is further complicating the quest for workable solutions.



BAE's production range includes the Hawk advanced trainer and light-attack twin-seater, sold to several air forces.

In addition, U.S. experts watching the European scene tend to underestimate the weight of "technicalities" such as the need to overcome challenges associated with very different social regulations, not to mention language barriers. However, in sharp contrast with politicians, industrialists gradually solved problems to transform

cross-border cooperation into reality. Fifty years ago, for example, a dozen airframe and engine manufacturers developed in common a maritime patrol and anti-submarine aircraft, dubbed Atlantic; its upgraded derivative is still operated by several navies. A few years later, France and the U.K. jointly launched the Concorde super-

sonic transport, which suffered from a complex industrial structure and excessive red tape. Sud-Aviation (later known as Aerospatiale) and the British Aircraft Corp., BAE's predecessor, nevertheless succeeded in developing the Mach 2 airliner.

Less than a decade later, Airbus was formed by France and Germany, joined by the U.K. and Spain and, after a difficult start, evolved into the world's biggest commercial aircraft manufacturer; while others created the Eurofighter Typhoon, the MBDA range of missiles and ATR twin turboprops. In other words, European cooperation has come a long way. This is probably the best reason to reject politicians' attempts today to interfere in the aerospace industry's consolidation strategy. Although governments are big customers, they should remain within the limits of their responsibilities and acknowledge that top executives understand market forces and the rules of the game better than government officials.

In the past several months, EADS Chief Executive Thomas Enders has repeatedly asserted that governments should relinquish their minority stakes in the multinational company. Sensitive military programs, such as France's nuclear ballistic missiles, can perfectly well be developed, tested and produced by a totally private company. The government, in its customer capacity, does not need to own a "golden share" to have access to the books and records and maintain rights, let's say, on the next-generation M51 missile.

To add some historical perspective, in 1936 a left-wing government nationalized the French aviation industry. Privatization followed, step by step, decades later but the cautious evolution has not yet been completed. Even though the French government owns no more than 15% of EADS, in today's consolidation context, its presence appears as a genuine error of taste.

The proposed EADS/BAE merger is more than a major European step toward global competitiveness. Establishing "the" global aerospace and defense company is also a nice way to tell lagging politicians that the time has come to readjust their focus and enter the 21st century. ☛



By Lee Ann Tegtmeier

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COMMENTARY

Data Harmonization

Mobility becomes increasingly important for aircraft and engine data

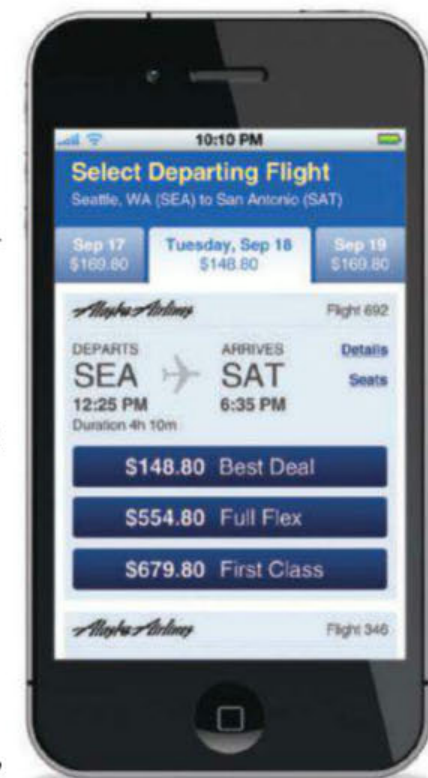
How would you define data harmonization and why does our industry need to strive for this? In preparation for our MRO IT Forum in Miami Sept. 19-21, I asked the industry via social media and LinkedIn groups for help with the definition.

First of all, a big shout out to the LinkedIn Aviation Service Lifecycle Management members and leader Michael Denis, InfoTrust vice president of customer engagement, for their specific and frank input! Denis kicked off the discussion by suggesting data harmonization should start with the end in mind, “a minimum set of open, business-to-business transactions at the data, content and knowledge levels, that enable transfers, across the entire ecosystem, which effectively and efficiently” improve airworthiness.

Most of the responders agreed that Spec 2000, a set of e-business specifications, products and services, covers the harmonization scope. Some people added ASD S1000D—a specification for procuring and producing technical publications—to this list.

Most members also agreed that the entire supply chain—OEMs, airlines, MROs and suppliers/distributors—need to be part of this.

A few responders highlighted that the “transport layer” of data harmonization could be a showstopper. In other words, how will the original creators of the data transfer the content. For instance, if .xml data makes its way into an Adobe.pdf, that data cannot simply



ALASKA AIRLINES

be integrated into another system.

One member suggested that if the industry uses the same data formats, the medium becomes less of a data issue and more of a business issue. As long as the data stays in a digital format—and is kept on CD-ROMs, in a cloud, a data warehouse or other electronic storage—then it is a business issue. But, the information absolutely needs to remain transferable digitally.

The thornier question is what data schemes should be open versus proprietary. Intellectual property rights are very real and important, but certain data need to be shared. This is a much debated subject. Finding a way to make everybody more efficient,

while protecting proprietary data, is not an easy problem to solve.

Jon Andresen, president of Technology Solutions, urged companies not to build too many of their “own” systems which can lead to “technological cul-de-sacs.” Walk into almost any airline and MRO and you will find many home-built systems and standardized software that has been modified. That is OK, as long as those systems work seamlessly in the long run with future data needs—and provide a road that goes somewhere—not just a circuitous loop.

Mobility is paramount.

Mobility Part 2

Switching gears to another area of mobility, airlines should really consider how easy or difficult it is for passengers to book tickets via their mobile devices. Alaska Airlines just launched m.alaskaair.com, which allows passengers to book a flight, check gate information, pay for bags or select a seat from their iPhones, Blackberries, or Android-powered devices or tablets. The airline also launched flight Status On the Go, a texting service that provides passengers similar features. For example, a passenger could text 825 and receive the following:

Alaska Flight Status

#825 - Thur. Sept. 13

Depart: SAN @ Gate 16

Sched: 7:00 a.m.

Actual: ETD 7:00 a.m.

Arrive: OGG @ Gate 5

Sched: 9:42 a.m.

Actual: ETA 9:42 a.m.

Given all of the devices and communication forms available, is your airline keeping up?

Maybe I have become more aware of this recently because I have a broken foot, yet another mobility issue, but being able to choose an aisle seat has become very important to me. If I cannot easily book a ticket and seat at the same time electronically, I will seek out a carrier that allows me to do that. ☺

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By Frank Moring, Jr.

Senior Editor Frank Moring, Jr., blogs at: AviationWeek.com/onspace
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COMMENTARY

Radio ISS

Space station radio testbed open for business

Researchers from industry, academia and government agencies now have access to the Space Communications and Navigation (SCAN) testbed on the International Space Station (ISS). NASA's Glenn Research Center hopes to begin demonstrations as early as late next year of new waveforms and software designed to enhance data delivery from scientific spacecraft. Announcements of opportunity to use SCAN are on the street, with industry and government researchers invited to enter Space Act agreements, and academic researchers to propose cooperative agreements. Researchers can develop and run new software on the testbed's software-defined radios, which can be upgraded and reconfigured from the ground through Glenn's Telescience Support Center to accommodate new types of data and correct inflight anomalies. Developed by General Dynamics and Harris Corp., the radios communicate through low-, medium- and high-gain antennas directly to ground stations or through NASA's Tracking and Data Relay Satellite System in S- and K_a-band frequencies (*AW&ST* June 25, p. 38). Initial checkout of the system, which is expected to operate for at least three years, started Aug. 13. ☐



ASTRIUM

PARADISE SPOTTED

The French Polynesian island of Bora-Bora gleams in 1.5-meter (5-ft.) resolution in this image collected by the new SPOT 6 Earth-observation satellite three days after its Sept. 9 launch from the Satish Dhawan space center on Sriharikota Island on an Indian Polar Sat-

ellite Launch Vehicle (PSLV-C21). Built by Astrium Services, the 800-kg (1,765-lb.) spacecraft images a 60-km (37-mi.) swath and can be complemented by 50-cm (20-in.) data from the very-high-resolution Pleiades 1A satellite, Astrium says. Indian space managers hope the SPOT 6 mission makes the PSLV a good candidate to launch the planned SPOT 7 bird as well. The launch was a first for India, with two foreign satellites riding on the 230-ton PSLV: SPOT 6 and the 15-kg Japanese microsatellite Proiteres, an Earth-observation technology demonstrator with a high-resolution camera developed by a team of students and faculty at the Osaka Institute of Technology. ☐

CANADIAN COMMANDER

Veteran astronaut Chris Hadfield is training to become the first representative of the Canadian Space Agency to command the ISS, with a two-month stint at the helm of the six-person orbiting science laboratory set to begin in March 2013. Hadfield, 53, has trained for two years with cosmonaut Roman Romanenko, 41, and NASA astronaut Tom Marshburn, 52, for a Dec. 5 liftoff aboard the 33 Soyuz mission to the station for a six-month tour of orbital duty.

As commander of Expedition 35 from mid-March to mid-May, Hadfield would become only the second non-American, non-Russian to lead a station crew. Eu-

ropean Space Agency astronaut Frank De Winne of Belgium became the first during October and November of 2009.

Under current scheduling, Orbital Sciences Corp.'s first Cygnus cargo vessel should arrive during Hadfield's command period, and he will be on the ISS for arrival of the third SpaceX Dragon cargo vehicle in January. If the scheduling holds, Hadfield, Romanenko and Marshburn will join ISS Expedition 34 commander Kevin Ford of NASA and cosmonauts Oleg Novitsky and Evgeny Tarelkin when the 33 Soyuz spacecraft docks with the station two days after lifting off from the Baikonur Cosmodrome in Kazakhstan. Hadfield would assume command when Ford, Novitsky and Tarelkin depart in mid-March. ☐

ADVANCED ROBOTICS

NASA will spend \$2.7 million on eight peer-reviewed research projects designed to advance the interagency National Robotics Initiative, set up by the Obama administration to promote U.S. robotics capabilities for the global marketplace. The projects will receive from \$150,000 to \$1 million for their work, which NASA's Office of the Chief Technologist is sponsoring as a way to push applications for "co-robotics" that can work with future human explorers on deep-space missions.

The projects are: the Florida Institute of Human Machine Cognition's "Toward Human Avatar Robots for Co-Exploration of Hazardous Environments"; "A Novel Powered Leg Prosthesis Simulator for Sensing and Control Development" from the Massachusetts Institute of Technology; Carnegie Mellon University's "Long-Range Prediction of Non-Geometric Terrain Hazards for Reliable Planetary Rover Traverse"; "Active Skins for Simplified Tactile Feedback in Robotics," at the University of Maryland; Purdue University's "Actuators for Safe, Strong and Efficient Humanoid Robots"; "Whole-Body Telemanipulation of the Dreamer Humanoid Robot on Rough Terrains Using Hand Exoskeleton" from the University of Texas; "Long, Thin Continuum Robots for Space Applications" from Clemson University; and "Manipulating Flexible Materials Using Sparse Coding" proposed by the State University of New York at Buffalo. ☐



By James R. Asker

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COMMENTARY

To a Higher Orbit

Politicians seek to take politics out of space

Aiming to remove politics from space policy—and attempting to get the attention of the presidential campaigns all but mute on space—some House Republicans introduce a bill that would overhaul the way NASA is funded and overseen.

The bill would create a 10-year term for the NASA administrator and call on the space agency to submit a budget directly to Congress alongside the administration's request that would have been vetted by the White House Office of Management and Budget (OMB). The bill would create a board to oversee the agency, similar to the way that the National Science Foundation is governed.

"We're going to finally get an honest, clear budget request from NASA, without being filtered by OMB," says bill sponsor Rep. John Culberson (R-Texas). "For the first time, we'll actually be able to see what it is that the best minds in the country believe is necessary to fund and fly America's space program." The bill would also extend a long-term contracting provision from the Evolved Expendable Launch Vehicle program to rocket propulsion systems, space transportation vehicles and related services. If the bill is passed by the House Science Committee in the lame-duck session after the election, the bill could be included in a full-year stop-gap funding resolution early next year, says co-sponsor Rep. Frank Wolf (R-Va.). ☐

DEAL, OR NO DEAL?

While most of Washington is growing more and more pessimistic about the potential for Congress to avoid a nearly \$1 trillion across-the-board federal cut, discussions about a possible deal are beginning to take



'Finally . . . a budget request from NASA without being filtered by OMB.'

REP. JOHN CULBERSON

shape. Then again, a \$4 trillion deal on deficit reduction is still a long way off, and how that would play out is highly dependent on the results of the November election. Senate Budget Chairman Kent Conrad (D-N.D.) says he and other senators are putting together an agreement that would delay the onset of sequestration by making the level of first-year cuts that sequestration would require and then creating a framework for a larger agreement to reform entitlements like Social Security and Medicare and rewrite the tax code. But that's all contingent on an Obama win, Conrad says. "If the new president comes in, there will not be this kind of grand bargain in a lame duck, because [Republicans will] want to wait for their guy to come in." ☐

MESSAGE RECEIVED

A frequent critic of the FAA's progress on the \$40 billion NextGen air traffic management (ATM) modernization program, Government Accountability Office (GAO) infrastructure guru Gerald Dillingham tells an industry gathering in Atlantic City, N.J., that the FAA needs to show some "little victories," if it ever hopes to get airlines off the dime to invest in avionics to make NextGen work. As in response, the FAA came through with a bit more just two days later. It

signed, sealed and delivered a \$331 million contract to Florida's Harris Corp. for what might be considered the third leg of the communications, navigation and surveillance (CNS) backbone for NextGen—the so-called DataComm contract. The other two legs, satellite-based navigation and Automatic Dependent Surveillance-Broadcast (ADS-B) are already in implementation. Under the 17-year data communications integrated services (DCIS) contract (seven-year base plus 10 one-year options), Harris will install a ground infrastructure network that will allow the transformation from an air traffic control system largely ruled by voice today to one dominated by secure and automated data transfer for all manner of command and control. The result is predicted to be a safer, more efficient, more economical national airspace system. A localized attempt at fielding datacomm failed miserably in 2004 with the collapse of the Controller-Pilot Datalink Communications program. ☐

PROBLEMATIC PORTFOLIO

Pity the Coast Guard. Tasked with a nearly impossible set of missions—the nation's fifth armed service is the principal agency responsible for maritime safety, security and environmental stewardship—it has never benefited from the budget largesse showered on its counterparts in the Defense Department after 9/11. Now comes word from congressional auditors that on top of relatively low funding, poor planning in Washington means that even though the Coast Guard has revised 15 out of 16 program baselines in its major acquisition portfolio at least once, 10 of those still do not reflect the actual cost or schedule of those programs today. In turn, the service is managing a portfolio that could cost more than \$35 billion, or 41% more than the original estimate of \$25 billion, says the GAO. Major programs out of sync, the GAO says, include the HC-130 long-range surveillance Hercules, HC-144A Maritime Patrol Aircraft, unmanned aircraft, HH-60 medium-range rotorcraft and newer HH-65 multi-mission Dolphins. ☐

Flame Out

Breakdown of its government/industry team plagues the F-35 program

Amy Butler **Washington**

The biggest threat to the stealthy, F-35 fighter program is not just the technical challenge of crafting three variants for three different purposes. It is not the engineering challenges—such as excessive weight, helmet integration problems or even software development. Nor the complexity of nine nations cooperating on the roughly \$400 billion program. It is not even the financial limitations, the serious squeezes on defense budgets and growing concern among customers about rising unit cost.

Those problems are daunting enough. But the man the Pentagon has tapped to direct the program has identified yet another. In a high-profile speech last week, U.S. Air Force Maj. Gen. Christopher Bogdan dropped a bombshell, saying the dismal relationship among stakeholders, the Pentagon's joint program office and prime contractor Lockheed Martin, is the biggest threat to its success. His remarks visibly disturbed senior Lockheed Martin officials sitting in the front

Problems that have arisen in flight tests, such as this routine one of an F-35A at Edwards AFB, Calif., are eclipsed by the bad relationship among the F-35's stakeholders, says the program's next director.

LOCKHEED MARTIN

row of the audience at the Air Force Association conference.

In a career of managing complex Pentagon programs, Bogdan says, "it is the worst I have ever seen." In some cases, the industry team takes seven months to respond to a request for data from the program office, he says.

Multiple current and former senior Air Force and Pentagon officials say the

approach taken by Lockheed Martin leadership in contract negotiations for the F-22 has carried into the company's practices for the F-35. Both programs are managed out of the company's aeronautics sector headquartered in Fort Worth. One official suggests that the company would intentionally stall the Air Force procurement staff in F-22 negotiations in order to protract talks dangerously close to the end of the fiscal year, when Pentagon comptrollers would reclaim unused funding from a program. This would force service officials to quickly conclude deals that were less beneficial to the taxpayer, the official says. That strategy worked for years, the official says, adding that contract terms were often disproportionately favorable to Lockheed on the F-22.

"These assertions are incorrect," Lockheed Martin spokesman Joe Lamarca says. "We negotiate all of our contracts with transparency and respect for our customers and suppliers."

But the Pentagon and Air Force officials maintain that this culture is permeating the F-35. Low-rate, initial production (LRIP) Lot 4 negotiations for the first fixed-price, incentive-fee production contract on the program took more than a year to conclude. In their midst last November, Lockheed Martin CEO Robert Stevens said in

company was exceeding target cost on earlier production lots by at least 15% and software delivery was lagging behind (a problem that persists). A month later, an agreement on cost sharing was reached, and the funding was delivered to Lockheed.

Now, however, LRIP 5 talks are dragging on. "It should not take more than a year to negotiate a contract, when you have been doing business together for 11 years," Bogdan says. Lockheed beat out Boeing for the F-35 development contract in 2001, and performance since has been plagued by overruns, design problems and delivery delays.

"We continue to work with our government customer to finalize an LRIP 5 contract that is mutually beneficial to the government, our international partners and the numerous suppliers and stakeholders to the F-35 program," Lamarca says.

Lockheed officials believe they have time on their side in these contract talks. Knowing the Pentagon has been adamant about keeping the unit cost of the aircraft down—under pressure from Congress—they argue that speed and momentum in the program are needed to quickly ramp up production and reduce unit price through high order quantities.

Though previous program managers backed that position, Venlet and Bogdan are taking a different tack. Bogdan is happy to allow talks to drag out. "We can slow down," he says. With this approach, Lockheed loses an advantage it had enjoyed for years.

Bogdan became deputy director of the F-35 five weeks ago; he must be confirmed by the Senate before ascending to the top program post, and his comments may have been aimed as much at skeptical Senators as at Lockheed.

But he did not speak without backing. Sept. 19, Deputy Defense Secretary Ashton Carter said, "We need a government-industry team that works together," adding that he is "with" Bogdan "100 percent."

A top priority is to "shed our baggage," Bogdan told reporters Sept. 18,

noting that program officials on both the government and industry sides who are not willing to cooperate will be let go.

This is not the first public admonition of the F-35 contractor; the relationship has clearly been strained for years. In January 2010, then-Defense Secretary Robert Gates announced a major F-35

restructuring, withheld \$614 million from Lockheed and fired the F-35 director at the time, Marine Corps Maj. Gen. David Heinz. A month later, then-Air Force Chief of Staff Gen. Norton Schwartz called out Lockheed Martin when asked if any officials on the industry team should be fired. "Dan Crowley [then-Lockheed F-35 program director] doesn't work for the Secretary of Defense" he said, indicating that the decision was under



Maj. Gen. Christopher Bogdan, incoming F-35 director

U.S. DEFENSE DEPARTMENT

Lockheed's purview.

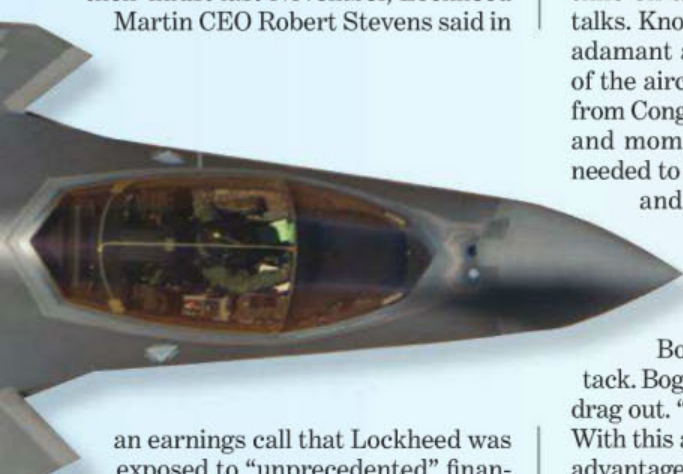
It took three months for the company to move Crowley to a corporate post in May 2010, installing the former F-22 program director, Larry Lawson, in the top F-35 job. Crowley now works for Raytheon. In April of this year, Lawson became executive vice president of the aeronautics sector, handing management of the F-35 over to Orlando Carvalho.

Despite the leadership changes, problems continue. One senior Air Force official says, "it is unfortunate that there are stressors and tensions that obviously bubbled up to the top," prompting Bogdan's comments.

The young F-35 production program has been characterized by contentious and protracted contract negotiations. Bogdan says it is unacceptable that the LRIP Lot 4 talks took more than a year, given that the partners have worked together for 11 years.

LRIP 5 negotiations are still ongoing after months, even though there is more actual cost data from previous lots to help with pricing. Though per-unit prices are coming down, they are still too expensive and Lockheed continues to exceed targets.

Bogdan could be considering an approach similar to the one he used with the Boeing KC-46A contract. After Boeing was selected over EADS to



an earnings call that Lockheed was exposed to "unprecedented" financial liability because the Pentagon was not paying \$1.2 billion in bills associated with advanced work on Lot 5 aircraft.

Vice Adm. David Venlet, F-35 director until Bogdan is approved for the post, refused to pay the bill until Lockheed agreed to a "concurrency clause." He wanted to share the cost of potential aircraft retrofits that would be required if deficiencies were found in the aircraft during development, which should wrap up around 2018. At the time of the negotiations, the

build the new aerial refueler, Bogdan negotiated a fixed-price contract that has been hailed by Pentagon leaders as an example of good acquisition practices. Boeing is taking a loss in the development effort on the assumption that it will make up the revenue later in production. The F-35 is the linchpin of Lockheed Martin's future aircraft manufacturing revenue stream.

In his remarks last week, Bogdan also signaled that Lockheed must be more attentive to the fighter's maintenance plan; some estimates peg the Pentagon's total ownership cost for 50 years at more than \$1 trillion, a staggering figure in this fiscal environment. Bogdan, however, says that Lockheed's position as prime contractor does not entitle it to control the life-cycle program. He opened the door to competing all or part of the life-cycle management of the massive aircraft program in the hopes of introducing innovation and affordability. "The basic strategy on the way we are going to sustain this program has got to change," he says, adding that government depots will also be considered for work.

Poor industry relations have nagged the Air Force for years, partly because of mistakes in its procurement of a combat rescue helicopter in 2006, a KC-135 replacement and, most recently, a light attack aircraft for use in Afghanistan. Confidence in the service has also eroded among lawmakers.

The protracted tanker competition marred the Air Force's relationship with Boeing. One senior Air Force official believes the service was stung by what officers saw as constant "end runs" by the company going to Congress for help.

Since then, however, Boeing and Air Force officials have "lowered their guard," to allow for a better relationship, says the senior Air Force official. Now, senior officials on both sides of the team meet routinely, and not simply when a problem crops up, the official says. The mistrust was fostered by overly complex protocols on both sides, the official adds, processes that have since been dismantled.

Maj. Gen. Steven Kwast, who heads requirements for Air Combat Command, called for "humility" on the part of industry and the Air Force in a speech at the conference. The parties need to "let go of our sense of control, and we need to collaborate to do the right thing," he says. ☐

Baby Steps

Fixes to F-35 tailhook, helmet progress slowly as software lags

Amy Butler Washington

Lockheed Martin is inching closer to solving some of the technical challenges encountered with the F-35 during developmental testing.

Trials of a redesigned tailhook for the U.S. Navy F-35C, designed for aircraft carrier use, are slated for next summer; arrested-landing tests were scheduled to begin this year.

But the original tailhook design failed to snag the arresting wire in early tests due to two problems: the point of the hook was not sharp enough to scoop under the wire and securely grab it, and a damper device was not sufficient to maintain a hold on the wire. Essentially, the hook was bounc-

plagued the program for more than a year with jitter, latency and other operational problems discovered in testing, says Maj. Gen. Christopher Bogdan, deputy F-35 program director.

Helmet performance is key to ramping up pilot training on the F-35, which is slated to begin early next year. Without this helmet—or possibly a backup model being quickly developed by BAE—the U.S. Marine Corps cannot declare operational capability as planned, as early as 2015. Bogdan doubts fixes to all of the problems will be implemented by then, but the government's plan to dedicate a test aircraft to the problem signals how critical the helmet is to the program's future.

Although he sees some "glimmers of hope" that production processes are improving, Bogdan notes that F-35 aircraft software is up to four months behind schedule. "There is an

awful lot of software on this program. It scares the heck out of me," he says.

Meanwhile, the latest delivery of the Autonomic Logistics and Information System (ALIS), an overall F-35 management tool, is due for November, according to Bogdan. Addressing security vulnerabilities caused the milestone to slip. Bogdan says the improved version should be validated by the middle of November, just as the Marine Corps plans to stand up its first F-35B squadron at Yuma, Ariz. Without the software improvement, the Marine jets will be grounded there, which Bogdan calls a "tragedy."

Problems with the ALIS 1.3-version software have also held up delivery of the latest aircraft from the F-35 final assembly line at Lockheed Martin's Fort Worth plant.

The massive F-35 flight-test program is ahead of schedule in terms of planned flights and test points, Bogdan says. "From my perspective, with the test programs, we are making progress, [but] I'm not sure we are creating the right progress," he notes. ☐

"There is an awful lot of software on this program. It scares the heck out of me."

ing upon landing, which reduced the likelihood of a successful arresting.

Lockheed Martin last month tested a partially redesigned version of the tailhook that features a sharper hook point but lacks the dampener that will eventually be incorporated. In three of eight recent attempts, the redesigned hook did capture the wire; the three failures occurred because the pilot landed the aircraft too far from the wire for a successful arresting. This testing "was highly successful in demonstrating that when presented the wire, . . . it will grab the wire," says J.D. McFarlan, Lockheed Martin's vice president of test and evaluation for the F-35 program.

The failures to grab the wire were predicted by models based on where the pilots landed the aircraft, McFarlan says. This helps to validate the modeling work done on the redesigned hook, he notes. Shipboard trials are set for 2014.

Meanwhile, program officials have set aside a single aircraft for up to 90 days of tests solely of the Vision Systems International helmet that has

Righting the Raptor

NASA weighs in on F-22 cockpit woes

Jen DiMascio Washington

The F-22 Raptor is renowned for its ability to sustain high-g forces at high altitudes. But keeping the aircraft safe from disaster in those extreme conditions has put a strain on the pilots, and the Air Force continues to struggle to strike the right balance.

The service is taking great pains to show that it has solved the physiological problems that prompted two pilots to tell the television magazine show "60 Minutes" in May that they did not want to fly the aircraft. The new chief of staff of the Air Force, Gen. Mark Welsh, declared during the recent Air Force Association's annual convention: "Don't believe what everyone's [saying] about people not wanting to fly the F-22. There is nobody asking out at the moment, that I know about." And Air Force Maj. Gen. Charles Lyon, director of operations at Air Combat Command, says the fleet has gone six months without incident and will be able to appeal to Defense Secretary Leon Panetta to resume flights above 44,000 ft. by year-end.

But a Sept. 13 House Armed Services Committee hearing on investigations into the aircraft's troubles highlighted the fact that F-22 program officials waved off a back-up oxygen system in 2005. And NASA rapped the Air Force on the knuckles for dismissing the health concerns of pilots.

The Air Force looked to NASA, twice burned by engineering failures that led to national tragedy, to study the lingering mystery surrounding pilot blackouts and what has become known as "Raptor cough." While the space agency's Engineering Safety Center found that the Air Force was on the right track, it also took the service to task for the kind of "normalization of deviance" that allowed engineers to overlook flaws on the Challenger before it blew up. "Differences in pilot breathing in the F-22 from other platforms was widely known and accepted as a normal part of flying the advanced aircraft," principal engineer Clinton Cragg testified. "The acceptance of these phenomena as 'normal' could be seen as a 'normalization of deviance.'"

The assessment found that a high concentration of oxygen at low alti-

F-22 Life Support Investigation Benchmarks

November 2010: Capt. Jeff Haney dies after F-22 crash during routine training mission in Alaska.

May 2011: F-22 fleet ordered to stand down.

June 2011: Air Force Scientific Advisory Board (SAB) begins study of F-22 incidents.

September 2011: F-22 resumes flights.

September 2011-March 2012: Pilots report 11 additional incidents.

January 2012: SAB delivers report to the secretary and chief of staff. Air Combat Command (ACC) establishes a Life Support System Task Force, which continues to examine both the issues of supply and quality of oxygen in the F-22.

April 2012: NASA accepts request to investigate ACC's ongoing root-cause analysis; and the F-22 life support system.

May 2012: Defense Secretary Leon Panetta restricts F-22 flights to below 44,000 ft. to allow for retrofit of valve in upper pressure garment.

August 2012: NASA Engineering and Safety Center delivers independent report to Air Force warning against a "normalization of deviance" in accepting F-22 health problems.

November 2012: Air Force to begin fielding upper pressure garment with new valve.

January 2013: First aircraft to receive backup oxygen system.

Sources: Scientific Advisory Board report; House Armed Services Committee hearing testimony; and Maj. Gen. Charles Lyon, director of operations at Air Combat Command

tudes can lead to "absorption atelectasis," in which too much oxygen can wash away necessary nitrogen within the lungs and cause lung tissue to collapse. The effects of high oxygen levels are compounded by the aircraft's "inevitable acceleration," Cragg said.

"Inappropriate inflation" of the pilots' upper-pressure garment further restricted breathing and reduced overall cardiac output, Cragg testified. "Un-

characterized F-22 life-support system vulnerabilities, such as pressure drops across components in the cockpit," were also flagged as contributors.

In the long term, NASA recommends end-to-end testing of the life-support system, environmental control system and aircrew flight equipment. The agency also recommends a reassessment of the life-support system in high-performance aircraft and a formal lessons-learned review of the Air Force-led investigation.

Lyon told lawmakers that in 2005 USAF rejected a back-up oxygen system that would have cost the government about \$500,000 to ensure that the additional 15.4 lb. did not weigh down the aircraft. The weight issue is no longer a concern. "The performance of the aircraft is so magnificent that 15 lb. is not going to hurt," Lyon says.

The general says he is looking at "intersections" among the findings of the Air Force's Science Advisory Board (SAB) and the NASA report that will be folded in with the final document he provides to Panetta. "Our work is not done," he says.

The oxygen concentration issue is still being addressed by the Air Force. For now, the service is expected to follow through on the recommendations of an SAB report that calls for replacing the upper-pressure garment, seeking a back-up oxygen system and another system to avoid ground collisions—in case of pilot blackouts. Lyon expects to retrofit the upper-pressure gear with new valves by year-end at a cost of \$3.7 million. The backup oxygen system will begin to enter the fleet in January at a fleet-wide cost of \$51 million. A \$26 million ground-collision avoidance system will also be added.

Lawmakers' reactions to the testimony are decidedly mixed. Rep. Roscoe Bartlett (R-Md.) says he hoped the hearing would ease the minds of pilots and their families. But Rep. Jackie Speier (D-Calif.) is not sanguine that the underlying cause has been found. "I'm just not convinced we have the answer," she says. "I think NASA needs to be privy to all the information. And all the reports should be made public."

Rep. John Runyun (R-N.J.) emphasizes that pilot safety must be paramount. "We understand that we can change the physiology of a machine, but we can't change the physiology of a human being," he notes. "We have to be really cautious." ☐

LO And Behold

Assessing Shenyang's new stealth fighter

Bill Sweetman and Richard Fisher **Washington**
and Bradley Perrett **Beijing**

China's unveiling of a second low-observable (LO) or stealthy fighter, a Shenyang product possibly designated J-31, followed the same pattern as the revelation of the Chengdu J-20 at the end of 2010: Photos were leaked via the Internet on the eve of a U.S. defense secretary's visit to Beijing. The not-too-subtle message, as the U.S. follows through with its plans to shift air and naval forces to the Pacific region, is that China's own military modernization is not slowing down.

The first images of the J-31 show that the aircraft is very different from the large, canard-delta J-20. The

du JF-17 fighter, minus the tapered "collar" that fair's the latter's nozzle into the aft fuselage. Thrust vectoring has been studied in China but has not yet been demonstrated in flight.

One common feature of the J-20 and J-31 is that both, from images seen to date, appear to be beyond an "X-plane" stage. Both are equipped with weapon bays; both are full-scale demonstrators, and neither appears to use any components of existing aircraft. However, the timing of the development of operational variants and full-scale production remains uncertain. China is continuing the development of con-

J-31 Specifications (estimated)	
Wingspan	37.5 ft.
Length overall	53 ft.
Height	15 ft.
Propulsion	2 X Klimov RD-93 engines Intermediate thrust: 11,000 lb. Maximum thrust: 18,300 lb.
Weight	
Operating empty weight	27,500 lb.
Internal fuel	16,000 lb.
Internal weapon load	5,000 lb.
Normal takeoff weight	49,000 lb.
Sources: AW&ST Research	

the attendant displays, the Shenyang University of Aeronautics and Astronautics (SUAA) presented a model of a twin-engine stealthy fighter with the F-60 designator on the canted vertical stabilizer. SUAA has been involved in UAV, UCAV and now fighter design work for Shenyang.

Late in June, a crudely covered full-scale fighter, without its vertical stabilizers, was openly transported on a flat-bed truck from Shenyang to Yanliang Air Base near the major aerospace city of Xian, home of the China Flight Test Establishment of the People's Liberation Army Air Force. At the time, there was speculation that this aircraft was intended for Yanliang's static stress-testing facilities. The aircraft shape was broadly similar to the SUAA model.

One reason for this difference, according to some Chinese sources, is that Shenyang's fighter may not be a fully air force-funded program, but an initiative derived from its losing competitor to the Chengdu J-20. The various plants of the Avic group, such as Chengdu Aircraft and Shenyang Aircraft, have a long tradition of rivalry. To overcome that, the group began bundling them together from 2008 into specialist subsidiaries in which they were supposed to work together. But the defense ministry opposed tight integration of the defense subsidiary—including Chengdu and Shenyang—in order to maintain closer control and probably to retain and foster competition among them.

But it is also possible that Shenyang's fighter does have an official sponsor: the Chinese navy. Shenyang is the builder of the navy's first carrier-based fighter—the Sukhoi Su-33-derived J-15. The J-31 would be more adaptable to carrier operations than the bigger J-20—although it might still need enhancements such as a bigger wing, an improved high-lift and control system, and thrust vectoring. Finally, the J-31 could be a smaller, less costly complement to the J-20. ☛

CHINESE DEFENSE BLOG



The tall vertical tails and clipped-delta wings of the J-31 recall the Lockheed Martin F-22, but the Chinese aircraft is smaller and lighter.

Shenyang fighter appears to be much smaller than the J-20, with about two-thirds as much installed power. It is a quad-tail design with a moderately swept clipped-delta wing and large canted vertical tails, with a similar overall layout to the Lockheed Martin F-22—but more like the F-35A Joint Strike Fighter in terms of overall size. Weapon bays occupy the entire lower body aft of the inlets and ahead of the engine bays (unlike on the J-20, there are no side bays). Flight controls are conventional, with separate rudders and single-piece flaperons.

As in the case of the J-20, most of the stealth-shaping techniques are very similar to those on Lockheed Martin fighters, but the engine nozzles are conventional. The nozzle shape on the prototype is close to that of the Klimov RD-93 engine installation on the Cheng-

du JF-17 fighter, and it remains to be seen when industry there can start producing competitive domestic engines and break the nation's dependency on imported Russian power. (So far, all production JF-17s have been RD-93-powered although a Chinese replacement, the Guizhou WS-13, is under development.)

Although there is no official information campaign for either of China's new stealth fighters, the "unofficial" information campaigns allowed to flourish on the Internet by government authorities have been markedly different, revealing much more about the Shenyang fighter.

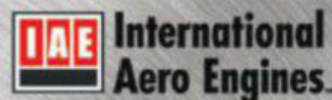
In September 2011, China's Aviation Industries Corp. (Avic) sponsored a competition for unmanned aerial vehicle (UAV) models at the China Aviation Museum outside Beijing, and as part of



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KF-X's Hurdles

South Korea's stealth fighter program encounters high-level political opposition

Bradley Perrett **Beijing**

No one ever accused South Korea's Agency for Defense Development of lacking ambition. But as it pushes ahead with its effort to indigenously develop a stealth fighter, the agency faces renewed accusations of a lack of realism, and it is simply being overlooked when it comes to funding.

The program is encountering severe political obstacles, with the finance ministry seeking to delay development and an influential think-tank casting doubt on the project's viability. Worse, a key opponent of the program may become defense minister in the next presidential term, which will begin in February.

The KF-X, intended to be larger than the Lockheed Martin F-16, would be more advanced than that aircraft but not reach the level of the U.S. manufacturer's F-35 Lightning. The agency, leading the project, is the repository of South Korea's most advanced defense technology and has produced designs that would be shaped for a low radar signature.

Development was supposed to begin next year, following concept definition this year, but the finance ministry's draft budget has dropped the previously planned funding allocation, allowing a mere 4.5 billion won (\$4 million) for further investigations. Subjecting the program to a second feasibility study in 2013-14 is one possible government measure, but it would add further delay.

Conceivably, parliament could restore the funding that the finance ministry has deleted, but lawmakers have tended to be opponents of the KF-X. Perhaps the most hostile of them, Yoo Seongmin, is expected to become defense minister if candidate Park Geunhye of the ruling Saenuri Party wins the presidential election in December.

Yoo is a former researcher with the Korea Development Institute, which reported in 2007 that the KF-X was not economically viable.

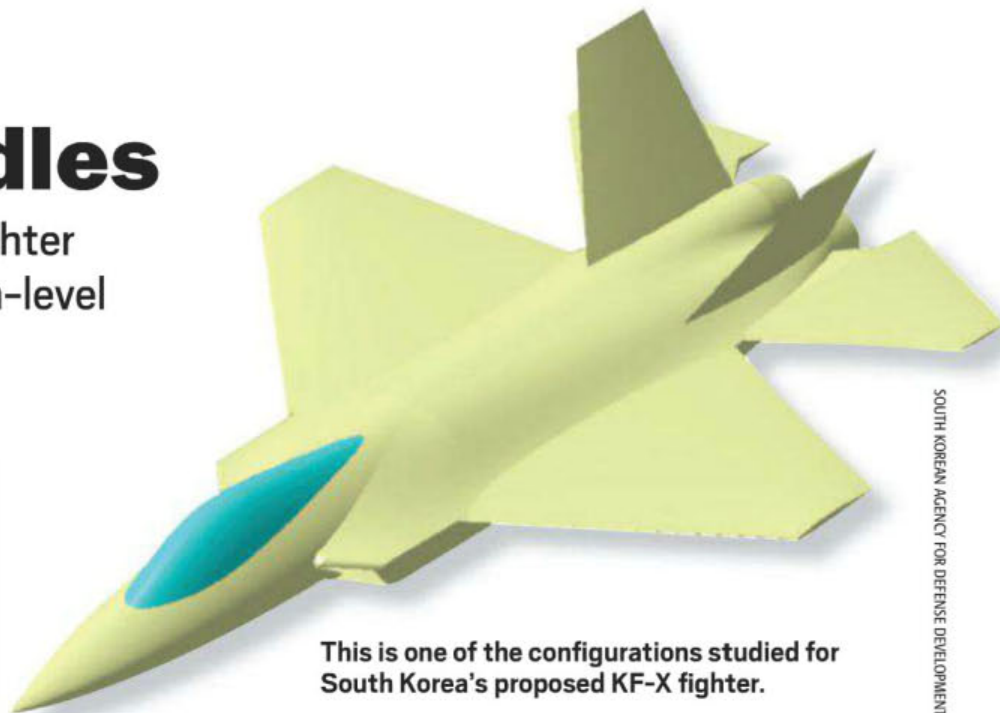
Another think tank, the Korea Institute of Defense Analysis, has submitted a confidential report questioning the project's viability, the Naeil newspaper says. That organization is attached to the defense ministry.

These blows to the KF-X program come as photographs have appeared showing a prototype of a similar Chinese fighter (see p. 28).

Yoo has called for South Korea to import aircraft, instead. Contenders would presumably include the F-35, Boeing F/A-18E/F Super Hornet and Eurofighter Typhoon. A compromise could be to improve a foreign fighter instead of developing a wholly new indigenous aircraft. But that would presumably give the foreign partner a veto over exports, and history suggests that the veto would be exercised.

Korea Aerospace Industries would be the prime contractor for the KF-X airframe and Samsung Techwin would probably build an engine of foreign design for it. LIG Nex1 would play a major role in the electronics fit.

South Korea's only previous indigenous jet combat aircraft is an armed adaptation of its T-50 trainer; the development of which was guided by Lockheed Martin. The Agency for Defense Development clearly requires outside help as it seeks to move to a next step of building a fighter that will be close to state-of-the-art. So the defense ministry has sought to use the current F-X Phase 3 requirement for 60 advanced fighters to extract a commitment from a foreign manufacturer to lend technical support to the KF-X development. South Korea's Defense



This is one of the configurations studied for South Korea's proposed KF-X fighter.

SOUTH KOREAN AGENCY FOR DEFENSE DEVELOPMENT

Acquisition Program Agency has asked Boeing, Lockheed Martin and EADS—contenders for F-X Phase 3—whether they can provide 51 technologies needed for the KF-X development.

"Whether a new mid-sized fighter we want to develop would really raise our technology level and benefit our air force should be thoroughly assessed," says Yoo. "It is a more important matter than fostering the growth and development of our aerospace industry." He cites the Dassault Rafale, a mid-sized fighter developed by France alone, as an example of dashed hopes, especially in exports, though India has now chosen to buy it.

Yoo also focuses on a contradiction often seen in South Korean defense policy: The country buys a lot of weapons and therefore feels it can build its own, but it buys a lot of weapons because it faces a serious threat from North Korea and can hardly afford to compromise on defense. "If the KF-X fails, our air force's force structure would face an enormous setback," he says. "So the next president's decision will be very important."

Concept definition of KF-X in 2011-12 cost 55 billion won, Yoo says, and he believes that full-scale development will need at least 6 trillion won, plus an unknown amount for production. He is the chairperson of the parliament's defense subcommittee.

Indonesia is contributing to KF-X development. South Korea tried to entice Turkey prior to that country opting to lead its own program. A principle of cooperation in KF-X is that the South Koreans are the leaders. ☐

The Third Way

Pratt in, Rolls out, GE stays on as U.S. Air Force advances adaptive-engine technology

Graham Warwick **Washington**

It has been almost three decades since the U.S. last set out to develop an all-new combat-aircraft engine, but more than 50 years since the turbojet gave way to the turbofan. Now the U.S. is embarking on development of a new generation of fighter engine with an architecture it considers as fundamental an advance as the turbofan was over the turbojet.

Being part of a research effort that could produce the dominant combat-aircraft engine of coming decades is critical for industry. So General Electric and Pratt & Whitney are breathing easier after being selected by the U.S. Air Force Research Laboratory (AFRL) for the Adaptive Engine Technology Development (AETD) program to mature fuel-efficient, high-thrust powerplants for post-2020 upgrades to the Lockheed Martin F-35 and future "sixth-generation" combat aircraft.

Roll-Royce's Advent core will go on test by early December, followed by the full engine in October 2013.

AETD is a follow-on to AFRL's \$524 million Adaptive Versatile Engine Technology (Advent) program under which GE Aviation and Rolls-Royce North American Technologies will demonstrate engines in 2013. Selection for AETD is a coup for Pratt, which in 2007 lost out to GE and Rolls in the Advent competition, but a blow for Rolls, which did not receive the nod for the follow-on program.

"When we were not selected for Advent, we did a lot of our own rig work," says Jim Reed, Pratt & Whitney's director of advanced engine programs. "But that only mattered if we were selected for AETD. We had to build a strong proposal." At stake is the potential development of fuel-efficient engines to upgrade the F-35 after 2020 and to power future Air Force and Navy air-dominance fighters that could enter service around 2030.

The last time the U.S. embarked on development of an all-new combat engine was in the early 1980s with the

launch of the Joint Technology Demonstrator Engine (JTDE) program, which led to Pratt & Whitney powering both the Lockheed Martin F-22 with the F119 and the F-35 with a further development of that engine, the F135.

Having succeeded in killing the GE/Rolls-Royce F136 alternative engine for the F-35, Pratt's supporters in Congress threatened to cut funding for AETD, fearing it was a backdoor maneuver to a competitive engine. But Air Force reassurances that its goal is to mature technology and not to de-

velop an engine—coupled with the selection of Pratt over Rolls—should defuse criticism of AETD.

tem technology to reduce combat-engine specific fuel consumption (SFC) by 25%, AETD will fully mature adaptive engines for possible early entry into engineering and manufacturing development (EMD) after 2020. As with Advent, there will be "significant" cost sharing by the contractors, says Lewis.

Advent and AETD are developing and maturing technology for engines with a "three stream" architecture. In addition to the high-pressure core and lower-pressure bypass streams of a conventional turbofan there is a third, outer flowpath that can be opened and closed. For takeoff, the third stream is closed off to reduce the bypass ratio and route more of the airflow through the core to increase thrust. In cruise, the third stream is opened to increase the bypass ratio and reduce fuel consumption.

The third stream can cool the cooling air used for thermal management



ROLLS-ROYCE

velop an engine—coupled with the selection of Pratt over Rolls—should defuse criticism of AETD.

"We will not produce a prototype engine, but run core engines," says Tim Lewis of AFRL's Propulsion Directorate. "All three proposals were technically acceptable, but funding drove us to select two of the three," he says. Rolls states that it is "disappointed by this decision but . . . continues to work with the Air Force Research Laboratory on important programs such as Advent and HEETE [Highly Energy-Efficient Turbine Engine]."

Where Advent is demonstrating high-pressure-ratio core and adaptive-fan, variable-bypass, low-pressure sys-

tem technology to reduce combat-engine specific fuel consumption (SFC) by 25%, AETD will fully mature adaptive engines for possible early entry into engineering and manufacturing development (EMD) after 2020. As with Advent, there will be "significant" cost sharing by the contractors, says Lewis.

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of the engine hot section, the fuel used as a heat sink for aircraft systems, and the walls of the augmentor and nozzle. The architecture can also reduce aircraft drag. Inlets are sized for maximum airflow on takeoff, but capture more air than the engine needs in cruise, resulting in spillage. The third stream can bypass the extra air, reducing spillage drag, and the additional flow can be used to fill in the aircraft boat-tail, reducing base drag.

AFRL calculates adaptive technology will improve engine fuel efficiency by 25% over the F135 powering the F-35, increasing aircraft combat radius by 25-30% and persistence by 30-40%. The engine could also help address the

anti-access/area-denial challenges posed by a potential conflict with an near-peer adversary such as China, says AFRL. This could be achieved via increasing supersonic-cruise radius by 50% and reducing the aerial-refueling tanker burden by 30-74%.

Under the 48-month AETD program, GE and Pratt will design engines with 25% lower SFC, but 5% more military (dry) power and 10% higher maximum (reheat) thrust than the F135. "We will take that engine through preliminary design review," says Reed. The engine must be sized to fit the F-35 with "only modest modifications," he says.

AETD will take adaptive engines to

tability may be the missing piece."

Phase 1 of the AETD program, which runs through mid-fiscal 2015, includes preliminary design of the engine and testing of annular-combustor and high-pressure compressor rigs. Phase 2, which will conclude in fiscal 2016, consists of fan-rig testing and an engine core test, allowing for a notional first full engine test as early as 2017.

"There will be additional focus on augmentor and exhaust technology that is not part of Advent," says Lewis. This will include developing an exhaust system that enables the low-pressure third stream to mix effectively with the higher-velocity core

to begin tests in October next year. Pratt will deliver an adaptive-fan test rig—developed largely with company funds—to AFRL in February/March "to jump-start us [on AETD]," says Reed. Although Pratt lost the Advent competition, Meininger says AFRL was able to come up with more funding to help it modify an existing rig by adding a third stream to a two-stage fan, putting the company on a "fast track" to compete for AETD.

For Rolls, there was some consolation this week when it began tests of a high-pressure-ratio compressor demonstrator under AFRL's HEETE program, which aims to demonstrate

technology to reduce specific fuel consumption by 35% for embedded engines in future subsonic transports and unmanned aircraft. GE has also delivered a HEETE compressor rig to AFRL, with testing expected next year.

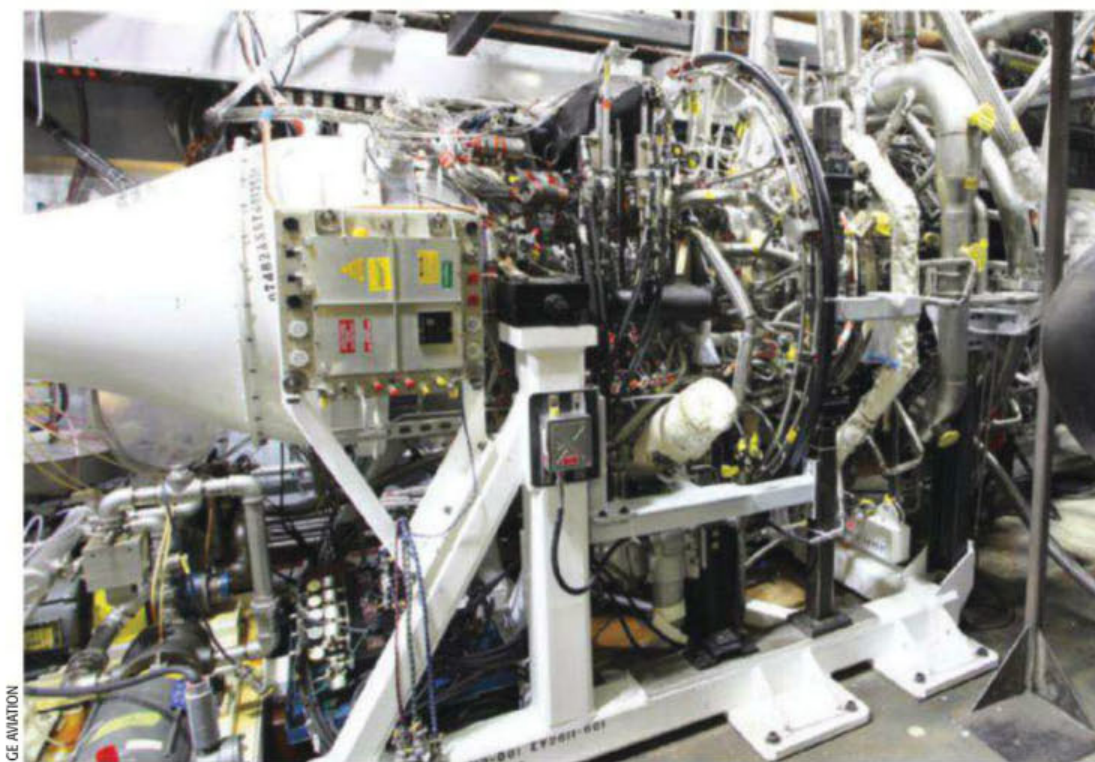
GE's Advent is to begin tests this week, with the full engine to run in July 2013.

Demonstration of a high-pressure core—compressor, combustor and turbine—is planned for 2016 under HEETE, with tests of a highly efficient turbine engine planned for 2019. Reducing SFC by 35% would increase transport-aircraft range by 50% and payload by

25%, and double the loiter time of intelligence, surveillance and reconnaissance UAVs, estimates AFRL.

Although funds are not available, the Air Force Research Lab would like to find a way to keep Rolls working on adaptive engine technology. "Each of the three companies has a unique architecture concept for the third stream," says Jeff Stricker, AFRL Propulsion Directorate chief engineer. "They have three approaches to adaptive fans and how to vary the third stream with the two main flows."

"We believe three-stream is the architecture for the next generation of aircraft," says Lewis. "Of course we would like to keep all three approaches available to us." ☐



"robust" technology and manufacturing readiness levels (TRL/MRL 6) in wait for a future EMD program, says Lewis. "Engines lead airframe development by several years and we need to be ready if and when they launch the next aircraft EMD," he says.

"The time is now for sixth gen," Reed says. "We may be 15 years away from needing an engine, but we have to start reducing risk now, because come 2020 we will need to begin an EMD program."

Manufacturers expect future fighters to require more thrust, better fuel economy and thermal management, and more electrical power generation. "But we don't know exactly what the transformational requirement will be for sixth gen, says Reed. "Adapa-

and bypass flows. "We will integrate an exhaust that produces thrust from the third stream," he says.

In parallel, studies with the airframers will identify potential applications of the common core beyond 2020. "We will conduct quantitative assessments of AETD-derived propulsion systems," says AFRL's Lewis.

GE, meanwhile, will begin high-pressure core tests this week under the Advent program. Rolls-Royce's LibertyWorks will begin testing its core in late November/early December, says Matt Meininger, AFRL's Advent program manager. GE's full engine is "75%-plus" complete and will go to test in July 2013, he says, while Rolls's engine is 90% complete and scheduled



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Tube Time

Production of communications satellites is hampered by assembly of key component

Amy Svitak Velizy, France, and Paris

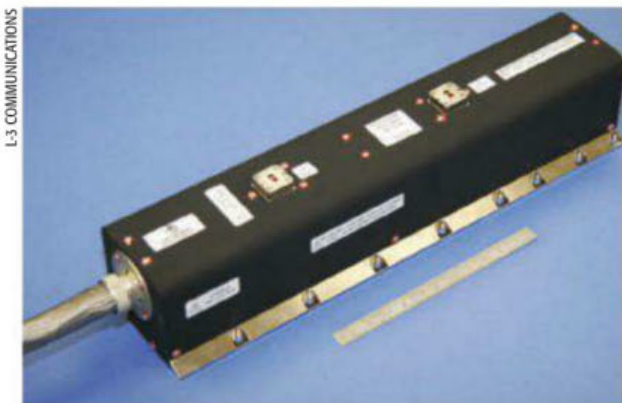
Traveling wave tubes and the process required to manufacture them have changed little over the past half-century. But these archaic vacuum-electron devices, known as TWTs, generate high-powered radio-frequency signals on some of the most advanced telecom satellites orbiting today.

Over the years, TWTs have become smaller, lighter, more powerful and efficient. But as satellite technology races ahead, production of these key components remains largely stuck in the past.

With global demand for faster and more affordable broadband on the rise, large satellite operators in Europe and the U.S. are starting to populate their fleets with high-throughput K_a-band communications satellites that can deliver high-speed bandwidth virtually anywhere on the planet. Over the next few years, the world's two principal TWT suppliers—L-3 Communications and Thales Electron Devices—anticipate a corresponding increase in TWT unit orders, in particular for high-frequency K_a-band tubes that generate huge amounts of spectrum power in the 18-40-GHz. range.

With close to 11,000 TWTs in space, Thales has more than 500 million hours

in orbit, “and 50 million hours being added each year,” says Jean-Francois Auboin, director of Thales space programs and engineering. When mated with a regulated power supply, TWTs are ideal for sending large amounts of data over long distances, providing more power and efficiency than solid-state radio-frequency transistors, he says.



L-3 COMMUNICATIONS

Both L-3 and Thales have seen an increase in orders for K_a-band wave tubes in the past few years. At Thales, roughly 50% of TWT units delivered in 2011 were in the K_a-band frequency spectrum, Auboin says. Although he anticipates the trend will continue, comparably ramping up TWT production capacity is easier said than done.

Built one at a time by hand, in production facilities redolent of the 1950s, K_a-band TWTs are assembled in a process

that is part engineering, part alchemy, a series of painstaking steps that can take up to a year to produce a single, functioning device.

Hunched over microscopes, tweezers in hand, workers at Thales's Velizy factory look less like radio-frequency engineers than jewelers soldering metal or setting precious stones. Rudimentary as the process may seem, the skill of assembling high-frequency-band tubes is costly and difficult to master. Once trained to assemble C- or K_u-band tubes, a worker cannot simply switch to building higher-frequency K_a-band TWTs.

“They are absolutely not interchangeable with some of the other bands,” says Jerry Ozovek, president of L-3 Communications Electron Technologies. “You can do training, obviously, but there is a certain knack to the K_a-band. It is a difficult product to build.”

L-3 developed this 200-watt K_a-band TWT and electronic power conditioner for NASA's Lunar Reconnaissance Orbiter mission.

Once a wave tube is assembled, a lengthy “burn-in” cycle ensues to confirm the stability of its cathode, focusing, power and gain. Thermal tests then monitor the device's performance across temperature cycles that simulate the vacuum of space, a test and verification process that can take months.

Most time-consuming, however, is the build, where individual piece parts and their precise configuration can differ depending on frequency and power needs. In K_a-band, “you're talking about literally what could be an infinite number of combinations and permutations in terms of configuration that are all driven by the platform designers,”

FLYING CLEEN

Guy Norris Los Angeles

Boeing tests of a range of advanced technologies to improve fuel burn, noise and efficiency are nearing completion with its 737-800 EcoDemonstrator, the company's first such dedicated flying testbed. The aircraft is on loan from American Airlines, which partnered with Boeing on the effort along with the FAA. The agency is providing \$125 million over five years toward the EcoDemonstrator under its Cleen (Continuous Lower Energy, Emissions and Noise) environmental program.

Flight tests began in late August at Boeing's facility in Glasgow, Mont., and are scheduled to be completed in the next few weeks in Seattle. The company stresses that technologies under study are not just aimed at potential application on 737s and derivatives, but at all sizes of Boeing aircraft. The advances range from near-term flight deck and navigation improvements to fundamental aerodynamic and propulsion features that could see service over the next decade or beyond.

Key technologies tested so far include the FAA-funded adaptive trailing edge, which could improve wing performance, as well as a Boeing and CFM-developed variable area fan nozzle. Among flight-deck and air traffic management technologies being tested are flight trajectory optimization and information

Ozovek says. "It's not as though you can buy the parts, put them on the shelf, wait to see who wins and then build their configuration."

Although a TWT is comprised of roughly 1,000 parts, only the vacuum tube is standard, leaving suppliers unable to stock parts in anticipation of demand. David Bair, technical director for satellite fleet operator Eutelsat, says component standardization at the prime level could remove a major obstacle for suppliers that is causing "choke points" in the timely delivery of K_a-band satellites.

"K_a-band tubes came into play very recently and put a real strain on the system," Bair says. "It slows things down and some [manufacturers] have bought tubes on speculation."

Martin Halliwell, chief technical officer at SES S.A., cautions that satellite manufacturers and suppliers need to react in unison for standardization to work. "It's the correct way to go, but we shouldn't underestimate how difficult this is going to be to get the entire industry to sign up for it," Halliwell says.

David Bernstein, senior vice president of program management at Space Systems/Loral, says harmonizing designs at the prime level could prove daunting, though some TWT components offer the potential for standardization. One example is the TWT base plate that serves as a mechanical interface between tube and spacecraft.

Bernstein says TWT base-plate designs vary in size and configuration and are determined largely by a spacecraft's mode of heat dissipation. Because heat dissipation is integral to the spacecraft architecture, a fundamental change in its thermal design would be costly, given the time needed

to develop, test and requalify a satellite.

"If you change your fundamental approach to thermal design, you're going to have to prove to the customers that it still works," a process Bernstein says can take several years.

Less drastic changes may be possible, however, such as harmonizing bolt positioning for base plates on competing satellite platforms.

"It's really understanding what flexibility each of us has in that interface and what things we can change and move and what things we can't," Bernstein says. "Certainly, if the tube manufacturers could improve their cost and schedule, we're willing to talk."

David Thompson, CEO of Orbital Sciences Corp., says a projected dip in orders for satcoms in the next two years, when large operators complete fleet replenishment cycles, could afford a window to harmonize equipment standards, "which might be more difficult to achieve in a period of high demand."

Arnaud de Rosnay, executive vice president for telecom satellites at EADS Astrium, says while standardization is a worthy goal, suppliers could do more to boost production. "I think it's more of a yield problem that I hope will improve with time," he says, referring to the fact that around 50% of K_a-band wave tubes are rejected during test and verification due to manufacturing defects.

"You have to scrap the tube if you can't get it focused," Ozovek says. "There's very little you can do in terms of rework."

Stephen O'Neill, vice president for commercial satellite systems, space and intelligence systems at Boeing, says he recently visited facilities at L-3 and Thales to assess production capacity.

"In both cases we were quite pleased to see the effort they've made to reduce lead times in the K_a-band area," O'Neill says, noting that the newness of K_a-band technology affords a slight learning curve for TWT engineers that is leading to higher yield rates.

Ozovek agrees: "We're closer to two out of three now, but it's still a big number that falls out of the process."

In the meantime, TWT manufacturers have remained leery of high-volume production since the early 2000s, when anticipated large numbers of telecom satellites failed to materialize, leaving a glut of unused production facilities. In the past six years, however, Thales has increased TWT manufacturing capacity 2.5 times to shorten production cycles that can take up to 18 months to deliver a full set of tubes.

"Our goal here is to increase capacity and to be able to start work on dedicated tubes more quickly," says Michel Cazaux, head of marketing for microwave and imaging subsystems at Thales Electron Devices.

Long-term supply agreements with primes that guarantee a certain level of volume could also ease bottlenecks and allow suppliers to invest in added capacity. "It may be a year before I have the improvements that investment is going to yield, but at least I have agreements that say I'm going to have product to push through that increased capacity," Ozovek says. ☐



TWTs provide more power and efficiency than solid-state transistor amplifiers. To see an animation of how a TWT works, check out the digital edition of AW&ST on leading tablets and

smartphones, or go to AviationWeek.com/twt



management systems developed with Boeing-owned Jeppesen, as well as a related onboard network system server. The trials also involve a new bank angle display designed to assist pilots in upset recovery maneuvers in the event of a loss of situational

awareness, and tests of more steeply angled low-noise approach and landing techniques. Upcoming evaluations, to be completed by Oct. 1, will test devices to reduce engine vibration and a regenerative fuel cell. ☐

EcoDemonstrator flights tested new iPad flight-deck applications and (in-set) propulsion-related improvements.

Deal Breakers

EADS is scrambling to gain approval for a merger with BAE Systems

Jens Flottau **Frankfurt** and Amy Svitak **Paris**

As Tom Enders tells employees in a letter, he is convinced that the planned merger of EADS and BAE Systems offers a “singular chance.” But there is a problem: Investors are notably uninspired and European governments lukewarm. There is a real possibility that the deal may still fall through.

The EADS CEO has been quietly briefing key government officials in France, Germany and the U.K. since early June in what should have been a long ground-laying process for more concrete negotiations in the fall. But then two unexpected events made the matter more difficult: A sporting accident forced Enders to cancel key meetings—among others, with German Chancellor Angela Merkel in August. And news of the plans leaked prematurely this month. Because the case is treated under British stock exchange regulations, the companies are now forced to come to an agreement among themselves and with shareholders and governments by Oct. 10.

Given the cautious comments made by the governments affected, it's uncertain if that deadline can be met, and officials are trying to assess the implications. With France being a 15% shareholder in EADS through the Sogeade holding, Germany being represented indirectly through Daimler (15%) and the U.K. having special control rights in BAE Systems, all three of them can block the deal if they wish.

There are clear signs that France will not sell its 15% stake in EADS in spite of the veto rights it may gain as part of the merger proposal. Whether Germany will buy up to 15% of EADS before year-end, as planned, is unclear.

That move was expected to balance power between France and Germany within the corporation.

Enders, who has been fighting political influence at EADS for years and has tried to dissolve the so-called shareholder pact, which gives core shareholders control over the company, is once again at the mercy of European governments.



EPA/LANDOW FILE PHOTO

Their concerns vary.

“We are discussing it and assessing what has been announced by EADS and BAE,” Merkel told journalists last week. She also indicated that her government is “in contact with others” and that Franco-German relations play “an important role.” Merkel and French President Francois Hollande were due to meet on Sept. 22 for an event commemorating Franco-German relations. The EADS/BAE question was on the agenda, too.

EADS and BAE are understood to have offered far-reaching concessions to the three main governments (France, Germany and the U.K.) in an effort to persuade them to approve the deal. They are offering veto rights through “golden shares” to be issued to each of them. In addition, EADS and BAE are including far-reaching employment guarantees to quell concerns

that work might be shifted elsewhere.

Germany's aerospace coordinator, Peter Hintze, a state secretary in the economics ministry, is known to be a fierce supporter of strict state control on jobs and workshares. He has clashed with Enders several times and might be the key person to persuade in German politics. Hintze, a prominent member of Germany's conservative CDU party, is known to be close to Merkel. The German side is already suspicious because Enders moved the EADS headquarters to Toulouse from Munich and Paris. If the merger goes ahead, the civil part of the business will be run from Toulouse, where Airbus is based, while the defense segment is understood to be headquartered in the U.K.

Government officials are concerned that German EADS facilities will turn into mere production sites, with the group being run out of France and the U.K. Several high-ranking members of

German Chancellor Angela Merkel, U.K. Prime Minister David Cameron (center) and French President Francois Hollande have to decide whether to allow the planned merger of EADS and BAE Systems to go ahead.

parliament also point out that the country is at risk of losing key defense capabilities over time. Given the lack of new large European programs, the sector is already in crisis mode and EADS has announced a restructuring of Cassidian, its defense division, that included the ousting of former CEO Stefan Zoller.

In France, a central issue is whether President Francois Hollande will accept privatization of EADS when the government appears keen to retain its special share and direct stake in the aerospace giant while preserving strategic programs, namely the French navy's EADS Astrium-built M51 nuclear missiles.

Following talks on Sept. 17 with his U.K. counterpart, George Osborne, French Finance Minister Pierre Moscovici said the proposal raises questions about French governance and jobs. Paris and Berlin are carefully reviewing the terms of the deal, he said, but a Franco-German examination of the proposal will take time.

“We are asking a lot of questions concerning the strategic interest of such a merger; the industrial effect, the possible synergies between the two companies, the governance of the entity, the future of our defense industry and

employment in France," said Moscovici.

Bernard Cazeneuve, French minister for European affairs, offered an even bleaker assessment, citing major technical roadblocks to the merger and suggesting it is likely to derail the linkup. He said a combined entity could make relevant Europe's common security and defense policy goals while positioning European industry to better face global competition. But the idea is not to shed jobs or abandon industrial roots in European territory, he stressed.

France also has to evaluate how Dassault and Thales would be affected by the EADS/BAE combination. The government has been highly supportive of Dassault in many cases, most recently the Indian fighter campaign in which the Rafale eventually prevailed over the Eurofighter and the Gripen.

On the other hand, if EADS and BAE are allowed to merge, the European governments will become even more dependent on a single big supplier. They have already learned what that may mean as a result of Airbus A400M program delays and the resulting price-increase negotiations. Enders at the time threatened to cancel the entire, already well-advanced project if governments were not willing to partly cover the billions in cost overruns. They eventually did.

There has also been a lively public debate in the U.K. about the deal. Concerns center around control over sensitive military programs and the security of British jobs.

Another key issue is going to be whether the European Commission will be ready to accept the golden-share set-up that EADS and BAE have been proposing. The EC has been highly critical of such special rights and has been trying to curtail them in other industries. They are possible, however, when it comes to defense interests. A spokesperson said the commission has not been notified yet and thus it was "too early to comment on this case and its possible outcome."

An analysis is also looming in the U.S., and rival Boeing may step up in leading industry opposition to the merger. "Boeing shares the concerns raised on both sides of the Atlantic that government and regulatory agency reviews of the proposed EADS-BAE merger must include a rigorous examination of a full range of complex industrial and national security considerations," the company stated. ☐

Warning Shot

Speea negotiators say 'no' to Boeing contract, putting labor peace at risk

Michael Meham San Francisco

Last December, Boeing Commercial Airplanes (BCA) bought labor peace with its machinists when it quietly negotiated a contract extension that will see it through a big buildup in deliveries of its popular 777 and 787 widebodies, peak deliveries in its 737 Next Generation narrowbodies and initial production and certification of the NG's successor, the reengineered 737 MAX.

But those grand plans will be tested in the coming weeks by BCA's other big union, the Society of Professional Engineering Employees in Aerospace (Speea), whose negotiating

Wearing union T-shirts to express their solidarity, engineers rallied in June for a new four-year contract.

committee recommended last week that its 23,000 members reject Boeing's four-year contract offer. "This offer is so terrible it's important for our members to see it and let Boeing know directly what they think," says Speea Executive Director Ray Goforth. Mailed ballots will be counted Oct. 1 on the single issue of whether the contract is acceptable, not on whether to strike.

The contract's Oct. 6 expiration date is not Speea's focus; sending a message is. The union has told Boeing's head of industrial relations, Vice President Gene Woloshyn, that the company is misreading how well negotiators understand their members. The vote will show who is right.

Since filing its own contract proposal on June 15, Speea's negotiators have complained about Boeing's lack of engagement. Boeing has responded with a so-called red-line contract as a starting point. The company expected to make a "best and final offer" after receiving Speea's feedback. Speea's decision to push the red-line offer as a litmus test of member sentiment amounts to an "unprecedented de-

parture from the normal negotiation process," the company says. Speea is counting on a resounding "no" vote to telegraph to Boeing that "it's time to get serious," says a union spokesman.

After six years of turmoil, all of Boeing's factories are hitting their stride. The Speea discord threatens this harmony.

The engineers' complaints are about



more than pay. After a 57-day strike by the International Association of Machinists in Aerospace (IAM) shut Boeing factories in 2008, the company decided to put a second 787 final assembly line in non-union North Charleston, S.C., rather than alongside the main unionized line in Everett, Wash. In the legal staff of the National Labor Relations Board, the IAM found a sympathetic ear to its charge that the move was an illegal retaliation for its strike. But the federal labor cops were taken out of the equation last year when the IAM accepted Boeing's contract extension, which includes assurances that the all-important 737 MAX development program will remain union-made in Puget Sound.

The IAM's militancy seems to have won the day; engineers have been far less willing to strike. Their only big effort came in a 40-day walkout early in 2000. But that does not mean there are not tensions between Boeing manage-

ment and Speea. The company's reliance on outside engineers—in Spain, Russia and elsewhere—to try to keep the 787 and 747-8 programs on track is as serious an outsourcing complaint for engineers as use of nonunion workers is for the IAM.

Speea complains that Boeing's current proposal endorses the use of contract engineers. Boeing uses them for temporary assignments; Speea wants Boeing's own ranks beefed up with permanent hires that will add to Speea's membership.

Boeing's proposal includes a 3% average annual salary increase for engineers and 2% for technical workers, rates Speea says are below aerospace industrial averages. It sought 7.5% a year for both groups. Other disagreements include the cost of medical benefits; Speea asserts that Boeing's proposal will require an 18% increase in what members must pay.

But one of the biggest sticking

Labor at Boeing

February-March 2000: Speea stages its longest strike, 40 days.

September 2002: Majority of IAM votes to strike, but not enough, so strike is averted.

September 2005: IAM stages 28-day strike.

September 2008: IAM stages 57-day strike.

October 2009: Boeing selects South Carolina as 787 assembly site.

December 2011: Boeing gains IAM peace with surprise four-year contract.

June 15, 2012: Speea contract talks begin.

Sept. 17: Speea negotiators say "no" to Boeing's proposal.

Sept. 20: Speea contract ballots mailed.

Oct. 1: Speea votes counted.

Oct. 6: Current Speea contract expires.

Source: AW&ST Research

points is Boeing's effort to shift incoming Speea members away from defined pensions in favor of a 401(k)-type employer/employee investment program. Boeing's concern is that at the end of 2011, it had an unfunded pension obligation of \$16.6 billion. The company

already has moved its non-union workers off defined pensions, but the IAM and Speea will not budge on the issue.

Speea says Boeing's proposal will mean new hires receive 40% less in pensions than current employees. The union's alternative is a measure of the difficulty Boeing faces. The engineers say they will accept 401(k)s only if Boeing funds them as highly as it does defined pensions. That, of course, does the company no good.

Others face the same issue. "We made the decision back in 2005 that all new employees would get defined contribution plans instead of defined pension plans," says

Lockheed Martin President Christopher E. Kubasik, who becomes CEO on Jan. 1. After a 10-week strike at its Fort Worth F-35 plant, IAM Local 776 received an 11% pay increase. But the machinists had to give up their defined pensions. ☐

SAFETY STRUGGLES

Jens Flottau **London**

Ryanair is facing an increasingly hostile debate in Spain about alleged safety lapses after the airline was recently forced to divert several flights inbound to Spanish destinations. Its CEO, Michael O'Leary, is fighting back.

Spanish Transport Minister Ana Pastor contacted the European Commission to call for more national oversight competencies within the EU. Pastor says "it is good to have lower fares, but we must not have lower safety standards." The transport ministry added that the regulation should be changed within weeks.

O'Leary reacted by publishing an open letter to Pastor in which he accuses Spain's aviation regulator (Agencia Estatal de Seguridad Aerea, or AESA) of having falsified Ryanair files alleging the airline was breaching Spanish law. "Ryanair again condemns the unacceptable behavior of certain officials within AESA and the Fomento [Spain's transport ministry], both in falsifying files to damage Ryanair and in making what are clearly inaccurate and untruthful statements," O'Leary writes.

The discussion was sparked by three incidents involving Ryanair aircraft over a three-day period in Spain, but it builds upon public sentiment that in order to be able to offer cheap fares, low-cost carriers must save on everything including safety.

One Ryanair aircraft hit midair turbulence leading to several injuries, another aircraft diverted because of an engine failure and the third because of another unspecified technical problem. There is no link connecting the incidents and Ryanair asserts that there are "absolutely no problems." The carrier points out that it operates around 1,500 flights per day.

The debate about safety standards at Europe's largest low-cost airline has been fueled by pilot unions in Spain and Germany, after three Ryanair aircraft had to declare emergencies on the same day in late July. The aircraft had to divert to Seville from Madrid because of a thunderstorm and were forced to circle in holding patterns for a substantial amount of time at the diversion airport before requesting priority landings.

The pilot unions claim Ryanair is putting pressure on flight-crews to take on the least possible amount of fuel for cost reasons. The carrier denies these claims. While investigations into the three events are ongoing, sources within the pilot community say the Ryanair crews almost certainly complied with regulations, and note that the events were likely triggered by an unusual set of circumstances. Ryanair has never had a serious accident. ☐

Gaining Ground

This time, the FAA's optimism over ERAM is supported by solid progress

Adrian Schofield

Tangible proof is finally emerging that the FAA is back on course with one of its most crucial—and most troubled—air traffic control programs. While government watchdogs caution that plenty could still go wrong with the En Route Automation Modernization (ERAM) effort, its accomplishments are at last beginning to outweigh the red flags.

This is welcome news for a program that has become the agency's poster child for cost and schedule overruns since its launch in 2003. ERAM, manufactured by Lockheed Martin, will be the foundation for much of the agency's NextGen air traffic modernization initiatives. It is the core operating system for all of the agency's 20 en route control centers, replacing the 40-year-old Host system.

ERAM is now operating in some capacity at nine centers, with five using it continuously as their frontline sys-

The ERAM system will be the core platform at the FAA's 20 en route centers.

tem. The other four are using ERAM for limited periods during the operational trial process. This means the FAA has largely achieved its goals for this fiscal year.

Recent progress is in stark contrast to the program's previous performance. Serious problems were discovered during operational trials at the first two sites, stalling further deployment. The FAA had to re-baseline ERAM in June 2011, with the new 2014 completion goal almost four years later than the original target. At the same time, the program's \$2.1 billion cost estimate rose by a further \$330 million.

The agency is on track to complete the operational rollout at all centers by 2014, acting FAA Administrator Michael Huerta told lawmakers at a recent congressional oversight hearing. Huerta says the revised estimates remain valid, and the agency has "hit the milestones we put in place" in mid-2011. "I think we have turned the corner on that program," he says.

U.S. Deputy Transportation Secretary John Porcari says that while it is not possible to guarantee there will not be any more problems, "I have a much greater level of confidence in where we are headed and the [program's] trajectory than a couple of years ago."

Transportation Department Inspector General (IG) Calvin Scovel, a



longtime critic of the FAA's efforts on ERAM, says the agency has made "a significant step forward" by introducing ERAM at the nine sites. He notes that testing at the two initial sites in Salt Lake City and Seattle "revealed extensive software problems with the system's core capabilities," which caused the lengthy deployment hiatus.

The program is not in the clear yet, Scovel stresses. "While FAA is making progress" in using ERAM at several locations, "it has not fully resolved critical software-related issues," he says. "Considerable risks remain to complete the effort within the agency's revised cost and schedule parameters." Analysis by the IG's office and Mitre Corp. shows that further delays are

possible, and that the cost overrun could rise to \$500 million.

During operational testing at the nine ERAM sites, controllers and technicians have identified and reported "in excess of 900 new high-priority software issues that need to be addressed," says Scovel. The FAA will not know the effect of these on schedule and cost until the issues have been assessed, he says.

However, Huerta says the issues with ERAM "are certainly not of that magnitude." In any operational system deployment, there will be software problems, he stresses, and "the important thing to focus on is their relative priority and how quickly they can be resolved."

The FAA tells Aviation Week that "only a very small percentage of the issues investigated to date on ERAM have been found to be linked to a new software problem." This proportion is less than 7% of the total.

The 900 issues referred to by the IG were identified at the centers that are running ERAM, but are not necessarily problems with software, the FAA says. Some are site-specific matters, and others are relatively minor concerns prompted by the new look of the system. "When an issue requires a software fix, it is prioritized and scheduled by a team" of personnel from the FAA, Lockheed Martin and the controllers union, the agency says.

Controllers are "enthusiastic" about ERAM, according to National Air Traffic Controllers Association President Paul Rinaldi. Natca will "continue doing what we can do to make sure ERAM is implemented on time and on budget," he says.

However, Rinaldi warns that staffing shortages present a major challenge. There are not enough certified controllers in the field to assist in testing ERAM software, particularly when multiple facilities test the system at the same time. This could hinder efforts to stay on schedule, he says.

The FAA will begin deploying ERAM at additional locations this fall. The 11 remaining sites include some that are more complex than any of the previous ones, Scovel notes. All of them are expected to reach at least initial operational status by the end of fiscal 2013. ☐

Maxed Out

Airport infrastructure in Asia fails to keep pace with growth in passenger traffic

Leithen Francis **Singapore, Jakarta and Bangkok**

Phenomenal growth in passenger traffic across Asia, particularly from low-cost carriers, has fueled demand for bigger airports. The authorities, however, have failed to address this need, leading to flight delays and slot constraints.

Nearly every major capital city airport in Southeast Asia has issues with congestion. The most notable examples are: Singapore's Changi, Bangkok's Suvarnabhumi, Manila's Ninoy Aquino International and Jakarta's Soekarno-Hatta International.

"When you start hearing stories about congestion at Changi, which is run by some of the most far-sighted people, then that rings alarm bells," says Andrew Herdman, director general of the Asia Pacific Airlines' Association, which represents 15 full-service network carriers.

Much of the airport congestion is a result of low-cost carriers (LCC), which use narrowbodies, says Herdman. These smaller aircraft result

in more departures. Some airport officials say the liberalization of air services, coupled with the success of low-cost carriers, has led full-service airlines to operate smaller aircraft in an effort to match the frequency of LCC flights. This too has added to the number of departures. Singapore Airlines, for example, previously only operated Boeing 777 widebodies to Kuala Lumpur and Penang in Malaysia.

But in recent years it has increased its frequency on these routes using Airbus narrowbodies operated by its subsidiary SilkAir.

Singapore's government is open about the fact that flight delays and slot constraints are now a problem at

Changi Airport. But the Civil Aviation Authority of Singapore (CAAS) has been quick to point out that efforts are underway to fix the problem.

CAAS's director general, Yap Ong Heng, says the authority last year introduced simultaneous takeoffs and landings at Changi.

Previously, the airport had one of its two runways dedicated to takeoffs and the other for landings. But allowing mixed-mode operations increases throughput.

Yap also says the airport has implemented a program to better coordinate activities there, such as ground handling. A real-time information exchange has been established so, for example, if a flight arrives earlier or later than scheduled, the ground handlers and others at the airport can respond more efficiently and avoid creating further delays.

Another ongoing initiative is to reduce the amount of time the runways are closed for maintenance, says Yap. This is achieved by boosting resources—equipment and people—so the jobs can be finished more efficiently and quickly.

CAAS has also introduced "one-minute" departures and changed some flight routes to allow for a reduction in aircraft separation. And



its air traffic controllers are being re-trained to ensure they make better decisions. For example, if thunderstorms are predicted, controllers manage the flow of air traffic earlier rather than later, helping to streamline operations.

These measures all help in the short-term, but are hardly a long-term solution. Changi's passenger traffic grew 14% last year and 9% in the first six months of this year.

Singapore's minister of state for transport and finance, Josephine Teo, says the government will decide before year-end whether to turn Changi's third runway over to commercial use. The third runway is currently reserved for the military. However, before commercial airlines can use it, the runway will need to be extended, she says. It also lacks taxiways to the passenger terminals, and a decision has to be made about what to do with the public road that runs between the second runway and the military runway. Yap says he anticipates the government will address these issues by year-end. Once the government approves the third runway, however, it will still take years before it is ready for commercial operations.

Many airports in Southeast Asia have grand plans for expansion, but unlike Singapore's situation, there are questions about whether these plans will be executed on time.

Thailand's Suvarnabhumi Airport began operations in September 2006 and a second-phase expansion was supposed to start a few months later. The authorities back then knew the initial capacity of 45 million passengers would be insufficient. However, political unrest in Thailand, following the military coup in September 2006 that toppled Prime Minister Thaksin Shinawatra from power, curtailed those plans.

The airport last year handled 48 million passengers and that number is forecast to grow to 52 million this year. Operating beyond capacity has led to lengthy queues at passenger immigration checkpoints, airlines often have to park aircraft at remote bays, new landing slots are hard to get, and aircraft are often delayed on the tarmac.

Thailand's current government, which was elected last August and is headed by Thaksin's sister, Yingluck Shinawatra, sees expansion of Suvarnabhumi as a priority.

Airports of Thailand (AOT) recently responded to government pressure by appointing EPM Consortium to manage the 62.5 billion Thai baht (\$2 billion) second-phase expansion project, which includes a concourse terminal with an adjacent 28 parking bays, and a tunnel and rail line that connect the concourse to the other terminal. The project also includes an extension to the existing terminal as well as construction of a new office building for airline companies. "Construction of a third runway is also in the plan, but the authorities still have to complete an environmental impact study," an AOT spokesman says. "If there is no problem, the third runway will be finished [at the same time as] Phase two," which is 2017. But a phase-three expansion may be needed fairly soon. Phase two will increase capacity to 60 million passengers per year, but AOT forecasts passenger traffic at Suvarnabhumi will reach this milestone in 2021.

Phase two construction, meanwhile, is only due to commence in late 2013. In an effort to relieve congestion in the

immediate term, the Thai government and AOT have decided some carriers are to relocate to Bangkok's Don Mueang International Airport.

Thai AirAsia, and its overseas affiliates that serve Bangkok, will vacate Suvarnabhumi and start operating from Don Mueang on Oct. 1, says CEO Tassapon Bijleveld. To entice carriers to move, AOT has granted a three-year discount on all airport fees and charges. The discount is 30% the first year, 20% the second, and 10% in the third. Tassapon says he plans to renegotiate with AOT for fourth-year discounts when the time comes. He also says the government has agreed to increase bus services to Don Mueang and that it is committed to working toward building a rail-line connecting the airport to the Bangkok train system.

Thai AirAsia is moving to Don Mueang because Suvarnabhumi's congestion had reached the point where "we were no longer able to grow there," says Tassapon. It also adversely affected the airline's on-time performance.

Thai Airways International, meanwhile, is keeping all its flights at Suvarnabhumi. The national carrier's executive vice president of strategy and business development, Chokchai Panyayong, says once AirAsia vacates, it will free up slots for Thai Airways to expand. Chokchai says the AOT still needs to do more to improve runway utilization. The airport was designed for 76 aircraft movements per hour, but currently 54-56 is the norm, he says.

Congestion at Jakarta's main international gateway, Soekarno-Hatta International, is also leading the Indonesian authorities and some airlines there to look at alternatives.

National airport authority Angkasa Pura II states that Merpati Nusantara Airlines, Garuda Indonesia's low-cost carrier Citilink, and Lion Air's new full-service carrier Batik Air are allowed to be based at Jakarta's Halim Perdanakusuma International Airport next year. Lion wanted Batik Air there and Angkasa Pura II agreed to this, and also included Citilink and Merpati to help relieve congestion at Soekarno-Hatta.

Soekarno-Hatta's passenger traffic grew 19% last year to 51 million—the fastest increase among the world's major airports. Its three terminals were designed to handle 38 million passengers.

Garuda CEO Emirsyah Satar says Angkasa Pura II's plan to upgrade the

A Singapore Airlines A380 is serviced at Changi Airport's new Terminal Three.



Fast-growing Garuda

Indonesia is grappling with capacity constraints at Jakarta's Soekarno Hatta International Airport. To listen to CEO Emirsyah Satar discussing the airport's problems and improvement plans, check out the digital edition of AW&ST on leading tablets and smartphones, or go to AviationWeek.com/garudaceo

airport's three terminals includes erecting a building between the first two terminals that will house customs, immigration and quarantine. But it is unclear when construction will commence.

Runway capacity also needs to be increased, says Satar. But it will be hard for the government to appropriate the land, he says. "From the airline's perspective, I am looking at how they can invest in more equipment . . . so the existing two runways can operate more efficiently."

Land constraints around Soekarno-Hatta and Halim airports, have the government looking at Karawang, in the western outskirts, as a possible new site. Officials from Indonesia's transportation ministry say construction of the new airport will start in 2015. That creates a dilemma for network carriers such as flag carrier Garuda Indonesia, which prefer to have operations based at one airport so passengers can connect to flights easily.

The Philippines government, meanwhile, is considering turning Clark, an airport outside of Manila, into the city's main international gateway. Some carriers, however, have resisted the idea, arguing Clark is too far from Manila and that unless there is a high-speed train and freeway connecting Clark to central Manila, the inconvenience will make it impractical.

But Manila's Ninoy Aquino International Airport abuts a dense residential area, making land appropriation almost impossible. It means there is no way the airport can have a third runway. The Manila International Airport Authority, however, has plans to increase throughput by realigning Runway 13/31 so it no longer intersects with the other runway. An independent slot coordinator has also been appointed to better manage slot distribution. And Philippine carriers have reduced their domestic schedules to help reduce congestion.

Meanwhile, Philippine Airlines CEO Ramon Ang wants to build a new airport for Manila. He can afford this because his family controls San Miguel Corp., one of the country's wealthiest conglomerates.

Ang declines to disclose the site of the planned airport, but says it is a nearly 5,000-acre site within a 15-min. drive of Manila's Makati business district. The plan will be presented to President Benigno Aquino, 3rd, in early 2013, Ang says. If approved, construction could start in 2013, with help from South Korean contractors, he adds. ☐

Overflowing Capital

Beijing's giant airport is at capacity, but work on a second facility has not begun

Bradley Perrett **Beijing**

Many a Western airline or airport manager, begging for better infrastructure, must gaze wistfully at China. There, it is so often said, "the government just gets things done."

And it often seems that when any level of government in China sees a need for roads, power stations, airports and the like, not much time passes before trees are crashing down and excavators are at work. A "Nimbyism" stance does not stand much chance.

But it is not always so. Repeated delays in beginning work on Beijing's proposed new airport seem to be driving the city, China's second largest, toward a nasty capacity crunch around the middle of the decade. If traffic is not crimped, then at very least conditions at the current airport will be pretty uncomfortable by the time the new facility

that fits Chinese tradition would be that once the airport had been delayed into this year, it had to be left as a project for the country's new leadership, who should be designated by year-end.

Either way, Beijing's traffic numbers speak for themselves. Capital Airport's designed capacity is 85 million passengers a year. It handled 79 million last year, up a surprisingly modest 6.4% on 2010. (Chinese civil aviation figures tend to grow in double digits.) On that count, it ranks behind only Atlanta's Hartsfield-Jackson International Airport.

Even at that low growth rate, Beijing should be at about full capacity now, and by 2017, when the new airport at Daxing (pronounced DAH-shing) is supposed to open, Capital would be handling 115 million people, 35% more than it was built for. Faster, and probably more

"More runway capacity will not help unless there is more capacity in the sky"

opens. Building a second big airport for Beijing this decade has been planned for at least eight years. For most of that time, construction was supposed to begin in 2010. But so far no sod has been turned.

"The big expansion of Beijing Capital Airport was just completed in 2008, and now only four or five years later they have run up to full capacity," notes Law Cheung-Kwok, of the Aviation Policy and Research Center at the Chinese University of Hong Kong. In those circumstances, work on further expansion or a new airport should have begun already, he says, adding: "It seems that the authorities have not been doing very good forecasts."

Or maybe they are just squabbling among themselves, as individuals and groups vie for control of the project and the benefits that come with it. It is hard to know what is going on in China's opaque politics, but such shenanigans are not unknown. Yet another theory

realistic, growth assumptions paint a worse picture.

Yet the situation could be even more dire, because Capital's giant new Terminal 3 is evidently not performing as well as expected. An official of the operating company says that opening an unused satellite building, supposedly needed for full capacity, would only provide more places to park aircraft, because bottlenecks have appeared elsewhere. He does not say where, but two years ago another official said Terminal 3 was limited by the handling capacity of the security checkpoints.

Worse still, Daxing may not be opened in 2017. That latest target was announced earlier this year as part of a plan that included beginning work this year. But the country's top planning agency, the National Reform and Development Commission, has not given its go-ahead. So work is unlikely to be underway until next year at the earliest. Schedules have consistently assumed a

five-year construction effort on the site, about 50 km (30 mi.) south of the heart of the city, Tiananmen Square.

While officials debate the merits of launching the Daxing project, further expansion of Capital remains a stopgap solution, even though that has supposedly been ruled out. Plans for a fourth runway have been studied, though the location of an additional terminal would be problematic. An airline official is skeptical about its merits. "More runway capacity will not help unless there is more capacity in the sky," he says, referring to congestion above.

The airports of the nearby cities Tianjin and Shijiazhuang are possible sources of interim capacity. In both cases, the expanded airports will have far more capacity than they can immediately use—25 million and 10 million passengers a year, respectively—and they are also intended to have high-speed rail connections that could make them practical for Beijing travelers.

Shijiazhuang is the capital of the province Hebei, whose government has promoted its Zhengding airport as a second facility for Beijing. The airport is 230 km from central Beijing, but the trains run at 300 kph (186 mph).

Beijing already has a second airport, because some civil traffic is allowed to

use the Nanyuan military field. The civil facilities there have been expanded to handle six million passengers a year, but the air force, long an obstacle to building Daxing, has agreed to close Nanyuan when the new airport opens, because their traffic patterns would conflict.

Under the latest plans, Daxing in its first stage will have a 700,000-sq.-meter (7.5-million-sq.-ft.) terminal designed for 45 million passengers a year. Plausible assumptions on traffic growth suggest expansion work might have to begin even as the first passengers arrive at the check-in desks.

Grandiose plans for nine runways, including one for military use, have been scaled back. Analyst Law wonders how so many runways could have been used, anyway. The current plan is for four—which Law notes will be more than adequate for the initial rated passenger capacity.

Perhaps reflecting the original scale of the plans for Daxing, 40 sq. km (15.4 sq. mi.) has been allocated to the development. There will be places for 220 aircraft and runway capacity for 650,000 movements a year, though that latter figure will depend heavily on developments in China's conservative air traffic management system. The forecast

cost is 80.3 billion yuan (\$12.7 billion).

Then there is the question of how best to divide the roles of two airports. A common answer is to send international traffic to the newer facility while domestic travelers enjoy the usually better location of the old one.

However, if that solution is applied rigorously, neither airport can then offer connections between domestic and international services. A different plan is eyed for Daxing: all members of the SkyTeam alliance will move there, say two airline officials who are familiar the plans. So Daxing and Capital, which will retain other airlines, will both serve as international-domestic hubs. The increasing importance of alliances seems to make this an ever more practical fix, since passengers are now quite likely to book connecting flights on partner airlines. ☛

Beijing Capital airport is running out of spare capacity, but expansions at Tianjin, Shijiazhuang and Beijing Nanyuan could help take some of the load while another big facility for Beijing is built. To view an interactive map of the five current and planned airports in the Beijing area, check out the digital edition of AW&ST on leading tablets and smartphones, or go to AviationWeek.com/beijingairports



Beijing Area Airports



Sources: Airports, Civil Administration of China and Chinese State Media

Capacity Crunch

Sydney needs another airport,
but reaching consensus will be difficult

Adrian Schofield **Sydney**

Australian leaders are trying to finally resolve a politically charged question that has vexed their predecessors for decades—where and when should Sydney's second airport be built? While it is making some headway, the government is faced with a tangle of conflicting interests that could stall the effort again.

The federal government is convinced that constructing a secondary airport in the Sydney area is a national priority. This view is echoed by Australia's major airlines, which say Sydney Kingsford Smith Airport faces serious congestion issues that will increasingly inhibit growth.

However, the government faces opposition at the state level, with the New South Wales (NSW) premier vehemently against a new airport. To further complicate the issue, Sydney airport officials say the urgency for a new facility is vastly overstated. And even if the second airport does go ahead, there is fierce debate about which of the possible sites would be best.

In an effort to cut through the confusion, the federal and state governments in 2009 assembled a task force to study airport capacity needs in the Sydney region. The panel earlier this year submitted a wide-ranging report, known as the joint study. It found that while the current Sydney airport should remain the primary gateway for the region, a second facility will be needed by 2030.

The report stated that although the issue is contentious, "the option of doing nothing is no longer available and the costs of deferring action are unacceptable." It assessed the merits of the potential locations and stressed that "there is a need to act quickly to finalize a decision on a site for a supplementary airport and secure it." As urban development spreads, the opportunity to build an airport "is likely to disappear altogether if action is not put in train now."

Australia's minister for infrastructure and transport, Anthony Albanese, is using the joint study to spur the bureaucratic process. He has ordered a

detailed investigation of a site in Wilton, southwest of Sydney. This was one of the two most viable locations identified by the joint study—although not its top choice.

"The clear finding of the [study] is that Sydney needs a second airport—sooner rather than later," an Albanese spokeswoman tells Aviation Week. Albanese wants "a real solution to Sydney's aviation capacity constraints," which is why he appointed experts to examine the suitability of Wilton, she says.

This analysis is expected to be finished within six months, and "will be used as a basis for helping the government decide whether or not to conduct a full environmental impact statement," which would be a key step for the airport project. The government must also hold talks with Sydney airport, which has first right of refusal to build and operate a second airport.

While it may appear to be yet another study, the investigation at Wilton

signals that the government is putting its weight behind this option. However, it has been unable to gain the support of the NSW state government.

"The Australian government has made its position clear throughout this independent and transparent process, and has repeatedly called on the NSW government to work cooperatively with [the federal] government to ensure we can meet the future aviation needs of Sydney and Australia," says Albanese's representative.

Despite the joint study findings, NSW Premier Barry O'Farrell remains opposed to a second airport in the Sydney region. This was a policy plank for his March 2011 election campaign. However, a spokesman for O'Farrell also notes that the second airport "is entirely an issue for the federal government [which] holds responsibility for airports."

Airport legislation gives the federal government broad acquisition powers, although pushing ahead with the project without the state's support would be difficult.

O'Farrell recommends upgrading Canberra International Airport as an alternative to another facility in the Sydney region. Canberra is 280 km (175 mi.) from Sydney, but a high-speed rail line could be constructed between the cities, he says.



Sydney Kingsford Smith Airport will inevitably reach saturation point, but efforts to decide on a second airport site are becoming bogged down by politics.

SYDNEY AIRPORT

Qantas CEO Alan Joyce is a strong advocate for a second airport, citing congestion at Sydney Kingsford Smith that is already causing flight delays. He argues that Canberra is not a realistic option, and has called for politicians to act soon to select a site near Sydney.

Virgin Australia welcomes the federal government's steps to "address the issue by opting for a second airport," according to an airline statement. "The general consensus [is] that Sydney will require a second airport within 15-20 years." The carrier says it has "no particular preference" regarding the exact location of a new airport.

The joint study found that many sites identified in previous assessments—dating back to the early 1970s—are now unsuitable due to development and other factors. The study's authors took a fresh look at options, and short-listed 10 sites.

The top recommendation is Badgerys Creek, a site to the west of Sydney that had also been earmarked by earlier governments. The government bought land there between 1986 and 1991 with the intention of building an airport, but both state and federal governments have since ruled this out. According to the joint study, Wilton is the next best alternative.

Other recommendations in the study

focused on allowing limited scheduled operations at the general aviation Bankstown Airport, and the Royal Australian Air Force's Richmond base. Improvements to Sydney airport were also proposed, including improved surface access, accelerating planned development, and raising regulatory caps on hourly flight movements.

These measures will provide only limited relief to the long-term capacity shortfall, the study says. Increasing the airport's footprint or adding runways is not possible, and the airport is also subject to a noise curfew.

The joint study estimates that all weekday slots between 6 a.m. and noon, and between 4 and 7 p.m., will be allocated by 2020. All slots will be allocated by 2027, and there would be unmet demand for 100 flights a day. By 2035, there would be no scope for growth.

In addition, road junctions leading to the airport will reach saturation by 2015, resulting in "a near constant traffic jam" on key access routes.

Sydney airport executives welcomed the joint study's finding that the facility should remain the region's main gateway. But while the airport agrees that a site should be secured for future use, it does not see an urgent need to build a new one. The airport stresses that it can provide capacity

for growth for a much longer period than the study indicates.

Analysis by the airport shows there is "ample capacity through to 2045," the airport's executive director for aviation services, Shelley Roberts, tells Aviation Week. As well as the airport's own construction plans, the changing nature of airline demand is helping to spread peaks and make them less congested, she says. "Once you get below the surface and actually look at what's happening, there is a dramatically different impression" of airport congestion.

International services have seen the biggest change. European destinations are increasingly being served through Middle Eastern hubs rather than via Southeast Asian stopping points such as Singapore, and there has also been an increase in point-to-point flights to Asian destinations. These dynamics have caused demand for slots in different times, helping to ease traditional peaks, says Roberts. The growth of low-cost carriers is also helping, as they are more likely to use off-peak slots.

In addition, aircraft upgauging has been a major factor in keeping operation numbers down. Since 2000 there has been a 40% increase in passengers at the airport, with only a 0.3% increase in aircraft movements. The average number of passengers per international flight has risen to 190, an increase of 60 from 25 years ago. The average is expected to climb to 290 over the next 20 years.

The busiest hour of the day is now less busy than it was in 2000, says Roberts. Almost 40% of available slots are unused, including some in peak hours. There is only one hour in each week where slots are fully used, she says.

The airport's own growth plans are also a factor. Even if it cannot increase hourly arrival rates, the airport will improve the capacity of terminals. It also aims to realign terminal use by co-locating international and domestic flights by the same airline, instead of splitting them between different terminals. This will help ease terminal congestion, as international and domestic peaks are at different times.

"At some point we are going to need a second [airport] site," says Roberts. "It's just that there's disagreement about the timing of that. With our new vision, we're saying it won't be needed before 2045, because we will continue to see upgauging and peak spreading" due to changing market trends. ☉



Major changes are planned at Sydney Kingsford Smith Airport to reduce congestion. To see an interactive exploration of proposed changes to the airport, check out the digital edition of AW&ST on leading tablets and smartphones, or go to AviationWeek.com/sydneyairport

Proof of Concept

Several new airlines are launched in Africa, but can they deliver?

Jens Flottau Addis Ababa, Ethiopia, and Frankfurt

Think tanks, analysts and politicians have been predicting the rise of Africa's economies and subsequent opportunities for air travel for many years. The forecasts, for various reasons, have often not turned into reality. But now it seems that foreign airline investors are gaining confidence in the region's growth potential.

Within a short span of time, several new African airlines have been launched with the support of outside investment. Some of them, such as ASKY Airlines in Togo or Korongo Airlines in the Democratic Republic of the Congo (DRC, or DR-Congo), are already flying and are gaining initial operating and market experience. Others—including Air Cemac, Air Cote d'Ivoire and the continent's first low-fare airline outside South Africa, Fastjet—are in various stages of planning.

They all see that many of Africa's economies have experienced strong growth recently, albeit from a low level. And they look at projections such as an International Monetary Fund forecast that sees the continent's GDP rising by an average 6.6% annually until 2015. Some countries, such as Ghana, Kenya, Nigeria and Angola, are expected to well exceed a 10% uptick until 2017.

As a result, business and leisure travel demand is heating up. According to a Liberum Capital study, African airlines will have offered a combined 84 million seats in 2012. That equates to one seat for 12,738 people. In the European Union, the ratio is 1.6 seats per person, and in the U.S. it is roughly 2.5 seats.

The bet is: Economic growth is continuing, and that will lead to more wealth creation and thus more people being able to afford air travel. According to the African Development Bank, the middle class has tripled in size during the past 30 years.

Following the size of national economies, South African Airways (SAA) is by far the biggest airline in the region with a 14% share of intra-African air travel. The top five also include Egyptair, Arik Air (Nigeria), Kenya Airways and Ethiopian Airlines. They control a combined 36% of the market.

While poor road and rail networks are often cited as one

argument favoring air travel, other shortfalls—particularly regarding airports and air traffic control—are still major problems that impede growth. Africa also has by far the worst safety record of all regions, and insufficient financial resources and oversight have meant that improvements are rare and slow.

The International Air Transport Association says the continent's safety record is "unacceptable." In July, IATA Director General and CEO Tony Tyler declared that "it is time for governments and industry to [devise] a strategic plan of action to make flying in Africa as safe as anywhere else in the world." On the other hand, Tyler is convinced of "the immense potential of African aviation to play an even greater role in the continent's development."

With the new projects lined up, things will change for the better, the investors argue. Among the many challenges they face may be one that many might not even be aware of: As Korongo has found out, foreign pricing tactics such as Saturday-night-stay clauses may not work in African markets and have to be adapted.

Air France-KLM is probably the most aggressive mover in developing new airlines in Africa. It is in the midst of preparations to launch Air Cote d'Ivoire and has reached code-sharing deals with Air Burkina and Air Mali. But its most difficult project is likely to be Air Cemac, an idea that has been around for 10 years.

Nevertheless, in August, the presidents of Cameroon, Republic of the Congo, Gabon, Equatorial Guinea, Chad and the Central African Republic formally decided to launch Air Cemac. It is to serve routes within the Cemac (Communaute economique et monetaire de l'Afrique centrale) economic zone and later add regional flights to other African destinations. The Cemac states had envisioned SAA as a partner initially, but the airline pulled out last year, opening the door for Air France.

"We want to start again to build partnerships with national airlines and participate in the creation of local airlines," says Air France-KLM Senior Vice President Pierre Descazeaux. "There is a need for reliable newcomers in this part of the world."

According to the initial plans, Air Cemac will be based in Brazzaville (Republic of the Congo), but Libreville (Gabon) and Douala (Cameroon) will be two additional important bases while the initial network will also comprise of Malabo (Equatorial Guinea), Bangui (Central African Republic) and N'Djamena (Chad). According to Descazeaux, "the main target is to serve regional routes, not only to feed Air France."

As part of the government agreement, the six states will take no more than a combined 33% stake in the airline. An additional third of the shares are to be held by Air France while local private investors are to control another third. That way,

Korongo Airlines is operating a single Boeing 737 (below) and uses two BAe 146s as backups.



governments can be sure that none of the other countries gains too much influence on the airline.

The management is to be a mix of local hires and Air France-KLM executives sent to Brazzaville.

The Air Cemac business plan, prepared by Air France, sees the airline operating an initial fleet of two Airbus A320s that will grow to four aircraft within two years. Descazeaux says the lack of a good database for travel demand makes planning difficult; thus, more flexibility is needed.

Unlike Korongo, a Brussels Airlines joint venture, Air Cemac plans to operate its aircraft with its own crews. Korongo is leasing aircraft and crews from its European parent.

Air France's first African joint venture, Air Cote d'Ivoire, is already set up. The European carrier has a 20% stake and flight operations were supposed to start in July. That has not happened, and Descazeaux says the delay should not exceed three months. The slip was caused by longer than expected negotiations with aircraft lessors, and now the Ivorian civil aviation authority has made clear that it will take its time to judge before it gives all necessary approvals.

New players are banking on economic projections that see the continent's GDP rising by an average 6.6% annually until 2015

Air Cote d'Ivoire will be based in Abidjan, the capital. The Ivorian government decided to invest in the new airline following the demise of Air Ivoire last year. The state will have a majority stake but the plan is to reduce it to below 50%.

KLM Royal Dutch Airlines, an Air France-KLM unit, also has a 26% stake in Kenya Airways, which is operating a major hub at its Nairobi base. Kenya Airways is also a member of the SkyTeam alliance.

As for low-fare Fastjet, it intends to launch services in November. Former EasyJet CEO Ed Winter leads the carrier, and EasyJet founder Stelios Haji-Ioannou holds a 5% stake. Fastjet is structured on the Fly540 regional airline but will be revamped using a fleet of Airbus A319s. Fly540 has been operating out of Ghana, Kenya, Tanzania and Angola. Fastjet, meanwhile, has selected Dar-es-Salaam, Tanzania, as its first base and will add Nairobi, Kenya, as its second once all the necessary approvals have been received. One of the issues in Ghana is a high departure tax that Winter hopes will be reduced to make low-fare air travel feasible. Winter sees Fastjet eventually operating up to 40 aircraft, which would make it one of the largest African carriers within a few years. But that implies that the conditions are right for low-fare players—lower departure taxes, efficient infrastructure to allow quick turnarounds, among other factors.

In the meantime, Congolese startup Korongo is looking at adding further routes in its home country after having gained initial operating experience in the four months since its launch.

Korongo currently operates two routes—six weekly round trips between Lubumbashi and Kinshasa in the DRC and four from Lubumbashi to Johannesburg. Most of those services are operated by the Boeing 737-300, while a BAe 146 is used only in the Kinshasa-Lubumbashi market.

Even though air transport could play an important role in fostering economic growth in Congo, political instability, corruption and a notable lack of infrastructure have hampered that development. Two other airlines besides Korongo currently operate in the country: FlyCongo has five aircraft (MD-82s) and serves six domestic destinations. It is built upon ex-Hewa Bora Airlines assets. Hewa Bora stopped flying last year. CAA (Compagnie Africaine d'Aviation) has a fleet of two A320s, one Fokker 100, four Fokker 50s and Shorts 360s, and serves roughly 30 destinations, most of them within the DRC.

Korongo's planned expansion is to be based on travel demand into and out of mining towns. Kolwezi, DRC, will be the next destination, followed by Mbuji-Mayi. The latter will be linked to both Kinshasa and Lubumbashi. A second BAe 146 has been added to the fleet to accommodate the additional services.

Flights within the region are to follow once Korongo has established a sizable presence in the domestic market. The reason that Korongo chose Lubumbashi as its base is because the airline expects strong travel demand, given that the city as an important center in Congo's mining industry. But the three weekly evening services are scheduled in such a way that passengers can connect to Brussels Airlines' late-night departure from Kinshasa to the Belgian capital.

While the 737 will be used almost at a full schedule, the 146s will have more ground time and will partially serve as backups.

Korongo is sourcing the aircraft plus crews on an ACMI (aircraft, crew, maintenance and insurance) contract from Brussels Airlines. Congo and all the carriers with a Congo base are blacklisted for safety reasons by the European Commission, thus they are not entitled to enter European airspace. The ACMI arrangement will continue until the blacklisting issue has been resolved.

The airline started out with a pricing system similar to what is typical in Europe and North America. It included features such as Saturday stays and little flexibility. "But we had to adapt," concedes Herman Carpentier, Brussels Airlines vice president for African sales. Korongo found that passengers are often not prepared to commit to a certain return flight when they book, and want more flexibility.

Around 30-40% of tickets are sold through travel agents, the rest in the carrier's city or airport office. There is no online booking tool yet.

Ethiopian Airlines, another big regional player, has launched Lome, Togo-based ASKY Airlines in connection with local investors to develop air service in population-rich West Africa, which generally lacks good air links. ASKY has been using Togo as its first base, but Ethiopian wants it to expand and operate from other locations as well. Accra, Ghana, is slated to be the next step, but "we are waiting for the airport renovation to be completed in Accra," says Ethiopian CEO Tewolde Gebremariam.

Accra was chosen because many Star Alliance carriers fly there and ASKY could provide intra-African feed, much more so than it currently does in Lome. Gebremariam admits that "ASKY's growth and load factors are good, but profitability is still a challenge." He hopes that negotiations with SAA and Egyptair will lead to both of them taking minority stakes in ASKY, but no firm agreement has been reached so far. When Ethiopian joined Star last year, there was even talk of a European partner such as Lufthansa helping to fund ASKY's startup, but none of this has happened. ☉

Narrow Focus

In the remaining months of 2012 and first part of 2013, attention in the commercial aircraft sector will be focused on narrowbodies, as Airbus and Boeing continue to rack up orders for their reengineed A320NEO and 737 MAX families and Bombardier works to get the CSeries into the air.

By the end of August, Airbus had firm orders for 1,456 NEO family aircraft while Boeing, which launched the MAX family a year later, had 649. Almost all the firm business so far is for the mid-range A320NEO (90% of orders) and rival 737-8 (82%). Including all types of commitment, the totals are 2,471 aircraft for the NEO and 1,609 for the MAX—extraordinary figures, given the A320NEO will not enter service until late 2015 and the 737-8 until 2017.

Bombardier has only 138 firm orders for the CSeries, but it still hopes to carve out a niche below the reengineed Airbus and Boeing narrowbodies when its 110/130-seat airliner enters service at the end of 2013. Studies of a high-density 160-seat version could help.

Embraer, meanwhile, has chosen to revamp its E-Jet family of large regional jets. The E-Jet EV program will reengine, and possibly rewing, the E-175, E-190 and E-195 and potentially add a stretched 130-seat version by 2018.

In the widebody sector, attention over the coming months will focus on Airbus efforts to get the first A350 into the air. First flight of the A350-900 is still expected before mid-2013, but production delays have pushed service entry back to the second half of 2014.

Boeing, meanwhile, is ramping up production of the new 787-8 and 747-8. The stretched 787-9 is expected to fly by mid-2013, with entry into service in the first half of 2014. Work is underway to define a stretched 787-10X for delivery late in the decade. A launch decision on the revamped 777X—stretched, reengineed and possibly rewinged to compete with the Airbus A350-1000—may come by early 2013 despite Boeing's recent reluctance to specify a timescale. The company still aims for entry into service by 2019.

The following profiles were compiled by Forecast International, which is also a resource for *Aerospace 2013*, to be published as a double issue dated Dec. 31, 2012/Jan. 7, 2013.

—Graham Warwick



Airbus A318 The A318 is a twin-engine, 107-132-passenger narrowbody jetliner. First flight occurred in January 2002. In May 2003, the A318 (with CFM56 engines) was certificated by the European Joint Aviation Authorities (JAA); this was followed by FAA certification in June and deliveries began in July. The A318 is powered by two 21,600-23,800-lb.-thrust turbofan engines, either the CFM56-5B or the Pratt & Whitney PW6000. Primary competition includes the Embraer 190 and 195 and Bombardier CSeries. **Airbus built 76 A318s through 2011, and 25 are forecast for production through 2021.**



Airbus A319/320/321 The initial A320 model in Airbus's family of twin-turbofan, narrowbody airliners made its first flight in February 1987. The A319 typically seats 124 passengers; the A320, 150; and the A321, 185. All three original models are available with a choice of CFM56 or International Aero Engines V2500 turbofans. In December 2010, Airbus launched the NEO reengineed A320 family, offered with a choice of either Pratt & Whitney's PW1100G or CFM Leap-1A engines. Deliveries are scheduled to begin in late 2015. Airbus will continue to offer its baseline A319/A320/A321 models. The direct competition for the A320 family includes the Boeing 737 series and Bombardier CSeries. **Airbus built 1,319 A319s, 2,860 A320s and 692 A321s through 2011. Including baseline and NEO models, production of 5,346 A319/A320/A321 aircraft is forecast for 2012-21.**



Airbus A330 The A330 twin-engine, widebody commercial passenger transport was developed by Airbus to replace aircraft such as the A300, DC-10-10 and L-1011. An A330 prototype first flew in November 1992, with deliveries following in December 1993. Customers have a choice of turbofan engines in the 64,000-72,000-lb.-thrust class: the General Electric CF6-80E1, Pratt & Whitney PW4000 or Rolls-Royce Trent 700. Three A330 models are available. The A330-300 seats 335 passengers in two classes or 295 in three classes. The -200 seats 293 in two classes or 253 in three classes. In 2010, deliveries began for the A330-200F freighter. The direct competitors are the Boeing 767 and 787. Production of the passenger models is likely to phase out in favor of the new A350. **Through 2011, 455 A330-200s, 364 -300s and 10 -200Fs were produced, with 417 A330-200/300s and 109 -200Fs forecast for 2012-21.**

Prepared in conjunction with Forecast International Inc., Newtown, Conn. For more information, contact Ray Peterson, Forecast International's vice president for research and editorial services at +1 (203) 426-0800, or email him at ray.peterson@forecast1.com

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Airbus A340 The A340 is a four-engine, intercontinental, widebody commercial transport aircraft. A prototype flew in October 1991, and deliveries began in January 1993. The A340-200 and -300 were certificated by the Joint Aviation Authorities (JAA) in December 1992 and FAA in February 1993. Both are powered by four 31,200-34,000-lb.-thrust CFM56-5C4 turbofan engines. Two newer models, the longer-range A340-500 and the stretched -600, are powered by Rolls-Royce Trent 500 engines. Typical seating for the -200, -300, -500 and -600 is 262, 295, 313 and 380 passengers, respectively. Airbus delivered 375 A340s through 2011. **The A340 program was terminated in November 2011 due to lack of orders.**



Airbus A350 Currently in development, the A350 is a twin-engine, widebody jetliner intended to compete with Boeing's 777 and 787. The A350 will be powered by Rolls-Royce Trent XWB engines rated at 74,000-92,000 lb. thrust and have a cruise speed around Mach 0.85. Three basic versions are being marketed: the -800, -900 and -1000. Depending on version, the A350 will seat between 270 and 350 passengers and have a range of 8,000-8,500 nm. An ultra-long-range version, the A350-900R, and a freighter, the A350-900F, are also planned. The A350-900 is scheduled to fly in 2013 and enter service in 2014. The A350-800 is due to enter service in 2016, while the -1000 is set to enter service in 2017. **Forecast International projects 817 A350s will be produced through 2021.**



Airbus A380 In developing the 525-passenger A380, Airbus chose to leap past Boeing's 747 in capacity class. Boeing is marketing the 747-8 to indirectly compete with the A380, but no direct rival exists in the 500-plus-seat market. The A380 is powered by four turbofan engines rated at 70,000-76,500 lb. thrust each and can be outfitted with either the General Electric/Pratt & Whitney Engine Alliance GP7200 or Rolls-Royce Trent 900. Airbus currently produces only a passenger version of the A380, delaying development of a freighter version until at least 2014. First flight occurred in 2005. **Airbus produced 71 A380s through 2011, with another 315 forecast for 2012-21.**



Airbus Military C212 The C212 made its first flight in March 1971, and deliveries began in May 1974. It is built under license by Indonesian Aerospace (IAe). Some 476 C212s (of all versions) were built through 2011. The C212 is an unpressurized, 21-28-passenger regional turboprop. The -200 model is powered by two Honeywell TPE331-10R-511C or -512C turboprop engines rated at 900 shp each. The -300 used two TPE331-10R-513C turboprops, also rated at 900 shp each. The latest model, the -400, uses two TPE331-12JR-701C engines rated at 925 shp each. IAe builds the NC-212-200 model in Indonesia, and the company has now assumed production and final assembly responsibility for the C212-400 as well. Airbus Military will reorient its production sites in San Pablo, Spain, toward production of the A400M. **The build forecast sees 33 new C212s for 2012-21.**



Aircraft Industries L-410 This 15-19-passenger, unpressurized, twin-turboprop-powered, regional/utility transport aircraft is powered by two General Electric M601 engines. GE is developing an improved H80 powerplant that combines the M601 design with GE-developed three-dimensional aerodynamics and new materials. The H80 features an extended service life of 3,600 flight hours or 6,600 cycles between overhauls, and improved hot-day takeoff performance and high-altitude cruise speeds. The engine requires no recurrent fuel nozzle or hot-section inspections. Service entry of the H80-powered L410 is planned for 2013. Besides building new-production L410s powered by H80 engines, the company also plans to market an H80 engine retrofit for existing M601-powered L410s. More than 450 L410s are in service. **Some 116 L410s are slated for production during the next 10 years.**



Antonov An-28/An-38/PZL-Mielec M28 The An-28 and -38 are twin-turboprop utility/transport aircraft. First flight of the An-28 occurred in 1969, with temporary Soviet certification following in 1978 and full certification in 1986. Production was transferred to Poland's PZL-Mielec, now a Sikorsky company. A Westernized version of the An-28, the PZL M28, made its first flight in 1993 and received FAA certification in 2004. A stretched An-28 version, the -38, made its first flight in 1994 and received Russian certification in 1997. The An-28 is powered by two PZL Rzeszow TWD-10B/PZL-10S engines, while Pratt & Whitney Canada PT6A-65B engines power the M28. The An-38-100/120 models are powered by Honeywell TPE331-14GR turboprops, while Omsk TVD-20 engines equip the An-38-200 variant. A total of 194 An-28s, 55 PT6A-powered M28s and nine An-38s were produced through 2011. Principal competition for the An-28/38 types comes from the RUAG Aviation Do 228NG and Viking Air Twin Otter. **An additional 45 M28s are forecast for production through 2021.**



Antonov An-124/An-225 The An-124 is a four-engine, intercontinental-range, heavy-lift cargo transport, while the An-225 is a six-engine, heavy-lift jet designed to carry the Soviet shuttle orbiter Buran. Initial flight of a production An-124 prototype took place in 1982, and commercial operation began in 1986. The An-124 is powered by four Ivchenko-Progress D-18T turbofan engines, while the An-225 is powered by six. **Fifty-five An-124s and one An-225 have been produced.**



Antonov An-148 The An-148 is a twin-engine regional jet designed to serve the 70-80-seat market. First flight took place in 2004, with type certification by Russia and Ukraine following in 2007. The An-158, a stretched, 99-passenger version, first flew in 2010. Power comes from two Ivchenko-Progress D436-148 turbofan engines. **Ten An-148s were built through 2011, and an additional 143 are forecast for production through 2021.**



ATR Series The ATR series are turboprop-powered regional transport aircraft. ATR is a joint venture of Alenia Aermacchi and EADS. The ATR 42 was first delivered in 1985 to Air Littoral, while the ATR 72 entered service in 1989. The latest versions are the ATR 42-600 and 72-600. The latter received EASA certification in May 2011. Both -600 variants are powered by a pair of Pratt & Whitney Canada PW127M engines, rated at 2,400-2,750 shp each. **A total of 969 ATR-series aircraft were produced through 2011, with production of 681 forecast for 2012-21.**



B-N Group BN-2T Turbine Islander The B-N Group BN-2T Turbine Islander is a rugged, relatively simple, twin-engine turboprop aircraft with standard seating for 10. It first flew in August 1980. The BN-2T is the latest, upgraded iteration of an aircraft design that dates from the 1960s and first flew with piston engines. The BN-2T is powered by a pair of Rolls-Royce 250-B17C turboprop engines, each driving a Hartzell three-blade propeller. A military variant, the Defender 4000, has slightly larger dimensions and uses a more powerful version of the Rolls-Royce 250-B17 engine. The BN-2T competes in this niche market against the Cessna Caravan, Pilatus PC-12, new Kodiak built by Quest Aircraft and reborn Do 228 made by RUAG. **An estimated 38 Turbine Islanders are forecast for production during the next 10 years.**



Boeing 737 The 737 series is a family of twin-engine, narrowbody commercial transports. Seating capacity varies depending on model, though the most typical two-class configurations accommodate 126 passengers for the 737-700, 162 for the -800, and 180 for the -900ER. All three models, which are the current production versions, are powered by two CFM56-7B turbofans. The first 737 flew in April 1967 and received FAA certification in December 1967. The 737 competes directly with the Airbus A320 family as well as the Bombardier CSeries. In response to the A320neo family, Boeing in August 2011 launched the 737 MAX, a reengined line of 737s. CFM International's Leap-1B has been selected as the engine for the -7, -8 and -9 versions of the 737 MAX. Rollout of the MAX is expected in 2015 and entry into service is targeted for 2017. **Boeing produced 7,010 737s through 2011 and is projected to manufacture 4,799 737s during the 2012-21 period.**



Boeing 747 The 747 is an intercontinental widebody commercial transport aircraft powered by four turbofan engines. First flight and certification occurred in 1969. In February 2010, Boeing first flew aircraft in the new 747-8 series: the 747-8 Intercontinental and 747-8 Freighter. Both versions feature four General Electric GEnx-2B engines rated at 66,500 lb. thrust each. The 747-8i is stretched 5.6 meters (18.4 ft.) compared to the 747-400 to accommodate 467 seats in a three-class configuration. The first 747-8 Freighter delivery, to launch customer Cargolux, occurred in September 2011. The 747's primary competitor is the Airbus A380. **A total of 1,444 747s were produced through 2011, with 209 forecast for the 2012-21 period.**



Boeing 767 The prototype 767 twin-engine, widebody commercial transport aircraft rolled out in August 1981, with first flight the following month. Through 2011, Boeing produced 1,014 of this commercial transport aircraft. Current models include the 767-200ER, -300ER, -400ER and -300F freighter. Typical two-class seating layouts are 224 seats for the -200ER, 269 for the -300ER and 304 for the -400ER. All three models are sold with a choice of GE CF6-80C2 or Pratt & Whitney PW4000 engines. The 767 has found a new lease on life due to the U.S. Air Force's KC-X tanker competition, for which Boeing has won the contract to supply 767-based aircraft. However, Boeing's new 787 will essentially replace the 767 in the commercial airliner product line. **Exclusive of militarized models, production of 107 767s is forecast for the 2012-21 period.**



Boeing 777 The 777 is a twin-engine, widebody commercial transport aircraft. First flight occurred in June 1994, followed by FAA/JAA certification in April 1995 (Pratt & Whitney-powered version). Deliveries began in June 1995. The 777-200ER version seats 301-440 passengers and is powered by two GE90, PW4000 or Trent 800 turbofans rated at 84,000-95,000 lb. thrust each. Two newer versions are the 777-200LR and 777-300ER. The -200LR, which seats 301 passengers in three classes, is powered by a pair of 110,100-lb.-thrust GE90-110B1 or 115,300-lb.-thrust GE90-115BL turbofans. The -300ER seats 365 people in three classes and is equipped with 115,300-lb.-thrust GE90-115B engines. A freighter variant, based on the -200LR, is also available. A 777X long-range, higher-capacity variant is under study for a service entry about 2019. The new Airbus A350 will be the 777's main competition. **A total of 983 777s were produced through 2011, and another 917 are forecast to be built in the 2012-21 period.**



Boeing 787 The 787 series is a family of twin-engine, widebody airliners. Two versions are marketed. The 787-8 carries 210-250 passengers and has a range of 7,650-8,200 nm. The 787-9, lengthened by 20 ft., carries 250-290 passengers and has a range of 8,000-8,500 nm. Both versions are offered with either two General Electric GEnx-1B or Rolls-Royce Trent 1000 turbofans producing 62,800-69,800 lb. thrust each. A third possible version, the 787-10, would be stretched another 20 ft. beyond the 787-9 and is being studied for launch later this year. The 787 received FAA and European Aviation Safety Agency (EASA) certification in August 2011, followed by delivery to Japan's All Nippon Airways of the first 787-8 the following month. Deliveries of the 787-9, production of which began in 2012, are not expected to begin until 2014. The 787's main competition is the forthcoming Airbus A350. **Production of 1,300 787 aircraft is forecast through 2021.**



Bombardier CRJ Series The CRJ series is a family of twin-engine, 44-100-seat regional jets. The initial model was the 50-seat CRJ100. It first flew in May 1991, and deliveries started in October 1992. The CRJ100 was replaced by the 50-seat CRJ200, which is powered by a pair of 9,220-lb.-thrust GE CF34-3B1 turbofans. Other variants have included the 44-seat CRJ440, which is also powered by CF34-3B1s; the 64-78-seat CRJ700, powered by two 13,790-lb.-thrust CF34-8C5 turbofans; and the 86-90-seat CRJ900, powered by two 14,255-lb.-thrust CF34-8C5s. Bombardier's Challenger 850 business jet/corporate shuttle is based on the 50-seat CRJ200LR. The newest is the CRJ1000, a stretch of the CRJ900, allowing a 100-passenger configuration. It made its first flight in September 2008, with certification following in December 2010. The CRJ100, CRJ200 and CRJ440 are no longer in production. In May 2007, Bombardier introduced next-generation versions of the CRJ700 and CRJ900, featuring operating cost improvements, an all-new cabin and increased use of composite materials. Primary competition comes from Embraer, though the Comac ARJ21, Sukhoi Superjet 100 and Mitsubishi Regional Jet may draw away potential customers in the future. **About 1,700 CRJs were delivered through 2011, with another 459 projected to be built in the 2012-21 period.**



Bombardier CSeries Launched in July 2008, Bombardier's CSeries family includes two basic models: the CS100 version, which is designed to carry 110 passengers, and the larger CS300 model, seating 130. The aircraft will be powered by two Pratt & Whitney PW1500G geared turbofans producing 21,000-22,900 lb. thrust each. Both the CS100 and CS300 are to be available in standard and extended-range versions, with the CS300 as an "extra-thrust" version as well. CS100 service entry is planned for late 2013, and the CS300 is to arrive about a year later. A high-density 160-seat version is under study. The CS100 will compete with the Embraer 190/195 and the Airbus A318, while the CS300 will vie against the Boeing 737 and Airbus A319. **Some 360 CSeries aircraft are forecast to be produced through 2021.**



Bombardier Q Series This twin-engine turboprop aircraft family initially was known as the Dash 8 series. The Q100, the original model, made its first flight in June 1983; first deliveries followed in October 1984. The Q100 carried 37-39 passengers and was equipped with 2,150-shp Pratt & Whitney Canada PW120/121 engines. Other models have included the 37-39-passenger Q200 (with 2,150-shp PW123C/D engines) and the 50-56-seat Q300 (with 2,500-shp PW123Bs). Production of the Q100, Q200 and Q300 has ended. The 68-78-seat Q400 (with 6,000-shp PW150As) remains in production. The main competitor to the Q Series is the ATR family. **Through 2011, 1,060 Q-series aircraft were produced, and an additional 369 are forecast in the 2012-21 period.**



Cessna Caravan This single-turboprop-powered utility/passenger aircraft first flew in December 1982. Designed with the small-package delivery segment in mind, the two models currently in production are the Caravan 675 and the 208B Grand Caravan. Power for both aircraft is provided by a Pratt & Whitney Canada PT6A-114A turboprop engine rated at 675 shp. **Through 2011, Cessna produced 2,107 Caravans of all types and is forecast to deliver 1,015 during the 2012-21 period.**



Comac ARJ21 Initially, the new ARJ21 regional jet from Commercial Aircraft Corp. of China (Comac) is to be available in the ARJ21-700 78-90-seat variant, while later introduction of the 98-105-seat ARJ21-900 is a possibility. Power is provided by two General Electric CF34-10A turbofans producing 18,500 lb. thrust each. Rollout of the first ARJ21-700 occurred in December 2007, followed by first flight in November 2008. The ARJ21 faces competition from Bombardier and Embraer. **Four ARJ21-700s were built through 2011, and 181 additional aircraft are forecast for production through 2021.**



Comac C919 A twin-turboprop-powered, narrowbody commercial passenger transport aircraft, the C919 targets the international Airbus-Boeing duopoly in narrowbody airliner sales. Variants include the baseline C919-200, which seats up to 168 passengers; the C919-100, a 130-seat model that will compete against the Airbus A319; and the C919-300, a 190-seat model designed to compete with the A321 and Boeing 737-800/-900. Comac has selected the CFM Leap-1C engine to power the C919. Service entry has been planned for 2016, but development is taking longer than anticipated. **A total of 130 aircraft is forecast for production through 2021.**



Daher-Socata TBM 850 The TBM 850 is a single-engine, 4-6-passenger turboprop-powered aircraft that replaced the earlier TBM 700 in 2006. Power is provided by a single 850-shp Pratt & Whitney Canada PT6A-66D engine. The aircraft has a range of 1,585 nm. **Through 2011, production totaled 260 aircraft; 418 more units are forecast for the 2012-21 period.**



Embraer 170/175/190/195 This is a family of twin-engine, 70-122-seat regional jet aircraft. The 70-80-passenger 170 made its first flight in February 2002, while the 78-88-seat 175 flew for the first time in June 2003. The 170 and 175 share the 14,200-lb.-thrust General Electric CF34-8E engine. The 94-114-seat 190 made its initial flight in March 2004, while the 106-122-passenger 195 first flew in December 2004. Additionally, Embraer has created the Lineage 1000, a business-jet version of the 190 that began delivery in 2009. Embraer is planning a comprehensive upgrade, including new engines, for at least three models in the family (the 175, 190 and 195). The 190, 195 and Lineage 1000 are all powered by 18,500-lb.-thrust CF34-10E engines. **Through 2011, 825 aircraft in this series were produced; an estimated 1,079 are forecast for the 2012-21 period.**



Embraer ERJ 135/140/145 The ERJ 135/140/145 family is a series of twin-engine, 37-50-seat regional jets. The initial model was the 50-seat ERJ 145, which first flew in August 1995; deliveries began in late 1996. The next model was the 37-seat ERJ 135, which made its initial flight in July 1998; deliveries began in July 1999. The 44-passenger ERJ 140 first flew in June 2000, with initial deliveries in July 2001. All models use variants of the Rolls-Royce AE 3007 turbofan. **Through 2011, 926 aircraft in the series were produced, not including the Legacy 600 or Legacy 650 business jet versions of the ERJ 135.**



GECI Skylander The French company GECI International and its Sky Aircraft subsidiary are developing a 19-passenger twin-turboprop called the Skylander SK-105. The Skylander was formally launched in September 2008. The aircraft is powered by a pair of Pratt & Whitney Canada PT6A-65B engines. **First flight is planned for September 2013, followed by certification and service entry in 2014.**



GippsAero GA10/GA18 The Australian company GippsAero is developing a 10-seat turboprop aircraft, dubbed the GA10, that is powered by a Rolls-Royce 250-B17F engine. The aircraft has a maximum takeoff weight of 2,154 kg (4,750 lb.). First flight of a GA10 developmental prototype occurred in May 2012, with Australian type certification planned by mid-2013. GippsAero is also developing the GA18 twin turboprop, which is based on the N24A Nomad. The GA18 will be reengineered with upgraded engines, new propellers, glass cockpit, weight-saving measures, reduced maintenance requirements and aerodynamic refinements. **Certification is planned for 2014.**



HAI Y-12 A 19-seat utility aircraft, the Y-12-II is equipped with Western avionics and Pratt & Whitney Canada PT6A-27 engines flat-rated to 620 shp each. The Y-12-IV has winglets, a strengthened undercarriage and redesigned seating. Another Y-12 version is the Y-12E, which is powered by 750-shp PT6A-135 engines. HAI is currently developing the Y-12F, which is substantially different from the earlier Y-12 designs. The Y-12F has a wider fuselage, retractable landing gear, and increased speed, range and payload. It is equipped with 1,100-shp PT6A-65B engines and Honeywell Primus Apex avionics. **A total of 57 Y-12-II/-IV and Y-12E aircraft are forecast for production in the coming 10 years.**



Hawker Beechcraft King Air Beech launched the King Air series of 8-12-seat, twin-turboprop aircraft in 1963. Since then, numerous variants have appeared. Total deliveries amounted to 6,225 aircraft through 2011. Hawker Beechcraft currently markets the King Air C90GTx, King Air 250 and King Air 350i. The C90GTx is powered by two Pratt & Whitney PT6A-135s producing 550 shp each. The more powerful 250 operates with two Pratt & Whitney PT6A-52s, rated at 850 shp each. The most powerful current King Air, the 350i, is equipped with two 1,050-shp Pratt & Whitney PT6A-60As. **Some 1,259 King Airs are expected to be produced in the 2012-21 period.**



Ilyushin IL-96 The IL-96 is a four-engine, medium-/long-range, widebody commercial passenger and cargo transport aircraft. The IL-96-300 first flew in 1988 and was certificated in December 1992. It is powered by Aviadvigatel PS-90A engines. The stretched IL-96-400 exists only as a freighter and is powered by uprated PS-90A1 engines. **Two IL-96-300s for government/VIP transport and 12 IL-96-400Ts are forecast for production in the 2012-21 period.**



Irkut MS-21 The Irkut MS-21 is a twin-turboprop, narrowbody airliner family that comprises the 150-seat MS-21-200, 181-seat MS-21-300 and 212-seat MS-21-400. All three are to be available in both basic and extended-range versions; the -200 is also to be available in a long-range variant. Power will be provided by Pratt & Whitney PW1400G or Aviadvigatel PD-14 engines. First flight is planned for 2015, with a service entry target date of 2017. Primary competition is likely to come from the Boeing 737, Airbus A320 and Comac C919 families. **A total of 123 MS-21s are expected to be produced through 2021.**



Mitsubishi Regional Jet Mitsubishi launched the Mitsubishi Regional Jet (MRJ) family in March 2008. Initially, two basic models are planned: the 78-passenger MRJ70 and 92-passenger MRJ90. Both will be powered by a pair of Pratt & Whitney PurePower PW1200G geared turbofans. Extended-range and long-range versions of each basic model are envisioned, while a 100-seater dubbed the MRJ100X is also being considered. First flight of the MRJ is planned for late 2013. Service entry is planned for the 2015-16 timeframe. **Some 182 MRJs are forecast for production in the 2012-21 period.**



Pilatus PC-12 This pressurized, single-turboprop-powered, corporate/utility transport aircraft first flew in May 1991, and received Swiss and U.S. certification in 1994. It has seating for nine passengers in its standard layout. Portugal's OGMA assembles green aircraft and also manufactures some components. The current PC-12 production version, the PC-12 NG (Next Generation), is powered by a 1,200-shp Pratt & Whitney Canada PT6A-67P turboprop engine. The PC-12 competes with the Daher-Socata TBM 850, Cessna Caravan and Hawker Beechcraft King Air. **A total of 1,104 PC-12s were built through 2011, and 854 are expected during the 2012-21 period.**



RUAG Aerospace Do 228NG Launched in 2007, RUAG Aerospace's Do 228NG (Next Generation) is an updated version of Dornier's original Do 228 twin-turboprop. The aircraft is powered by 776-shp TPE331-10 engines and features other improvements such as a new glass cockpit, five-blade propellers and aerodynamic changes to the wing. The first RUAG-produced Do 228NGs were delivered in 2010. **A total of 62 aircraft are forecast to be built during the 2012-21 period.**



Sukhoi Superjet 100 The Sukhoi Superjet 100, formerly known as the Russian Regional Jet, is a family of twin-engine transports powered by Snecma/NPO Saturn SaM146 turbofans, rated at 13,500-17,500 lb. thrust each. The series has been launched with the 95-98-seat baseline Superjet 100-95. The shortened 100-75, a 75-78-seat version, and stretched 100-115/120, a 115-120-seat version, are being considered. The Superjet 100-95 made its first flight in May 2008 and achieved initial Russian/CIS certification in early 2011; deliveries began in mid-2011. **Production of 227 Superjet 100s is forecast for 2012-21.**



Tupolev Tu-204/214 A twin-turboprop, short/medium-range, narrowbody commercial transport aircraft, the Tu-204-100 is powered by Aviadvigatel PS-90As, while the Tu-204-120 has two Rolls-Royce RB211-535E4 engines. The Tu-214 has a higher maximum takeoff weight (244,162 lb.) than the Tu-204-100. It retains the PS-90A powerplants of the -100 but carries additional fuel. The Tu-204's first flight occurred in January 1989. **Through 2011, 85 Tu-204s and Tu-214s were produced and 52 aircraft, including the new Tu-204SM variant, are forecast to be produced in the 2012-21 period.**



Viking Air DHC-6 Twin Otter Series 400 Viking Air owns the manufacturing rights to a number of out-of-production de Havilland aircraft, including the DHC-6 Twin Otter. The Series 400 is an all-metal, non-pressurized, high-wing, twin-engine turboprop utility aircraft. In April 2007, Viking Air launched a program to restart production of the 19-passenger Twin Otter. The updated Series 400 incorporates more than 800 changes to the Series 300 and is now powered by a pair of Pratt & Whitney Canada PT6A-34s or optional PT6A-35s. First flight occurred in February 2010, followed by Transport Canada certification in June 2010 and initial deliveries in July 2010. **Production of 152 aircraft is forecast 2012-21; seven aircraft were completed through 2011.**



Xian MA60/MA600 The MA60 twin-turboprop transport aircraft is a stretched version of the Xian Y7-200A, in turn a variation on the Antonov An-24. Accommodation can be provided for 52-60 passengers. The aircraft is powered by two 2,750-shp Pratt & Whitney Canada PW127J engines. Initial flight and delivery of the MA60 took place in 2000. A freighter version, called the MA60-500, is also marketed. In May 2010, a new variant, the MA600, was awarded certification by the Civil Aviation Administration of China. The MA600 features reduced weight, an upgraded cabin, new avionics (the Rockwell Collins Pro Line 21 suite) and a host of other improvements. Eventually, the improved and more advanced MA600 may supplant the MA60 in production. Through 2011, 66 MA60s and three MA600s were produced. **A total of 155 MA60/MA600s are forecast to be built during the 2012-21 time period.**



Xian MA700 Xian is developing a twin-turboprop regional airliner dubbed the MA700. This aircraft is not an MA60 variant, but rather a clean-sheet design. Features include six-blade propellers, a T-tail and an unswept high-mounted wing. There are two versions of the MA700: one with 70-plus seats and one with 90-plus seats. A dedicated freighter variant has also been considered. Service entry of the MA700 is targeted for 2016 or 2017. Xian intends to pursue FAA and European Aviation Safety Agency certification for the MA700. **The MA700 could replace the MA60/MA600 in production.**

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Aviation Week & Space Technology
September 24, 2012 VOL. 174, NO. 34 (ISSN 0005-2175)

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**AVIATION WEEK
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Rethink Familiar Business Models



Michael Goldberg leads Bain & Co.'s global aerospace and defense practice. He is based in Los Angeles.

Most defense company executive teams are spending a lot of sleepless nights these days. Their worry: how to create shareholder value in a market with a gloomy long-term outlook. Defense and security budgets are heading south. "Sequestration" looms large on Capitol Hill. New program starts are few and far between. Internally, most companies' cost structures are bloated from a 10-year growth cycle, and organizational complexity is rampant.

With that backdrop, how does a defense contractor make itself an attractive investment for shareholders? So far, we see A&D companies undertaking familiar strategies. They are reducing costs by streamlining their organizations. They are acquiring more companies in hopes of strengthening core businesses, filling capability gaps or gaining access to new customers. They are pursuing adjacent markets by chasing international contracts and new end markets such as health care.

“At a time when the customer should be encouraging innovation, it is loading on new requirements, more auditing and tighter rules around competitions.”

These strategies can create significant value if executed well, but each has limitations. Then there is another, newer strategy: business model innovation. This involves developing innovative offerings or delivery models to meet customers' needs at less expense—an urgent objective, given the government's struggles to achieve its diverse objectives with fewer dollars. So far, we have seen four primary types of business model innovations emerge:

- **Managed services.** Providing a product or offering based on customer usage, allowing the government to avoid owning the asset. Example: the power-by-the-hour model used by engine OEMs.
- **Commercialized offerings.** Investing internal capital to develop an offering that can be sold off-the-shelf, such as Harris Corp.'s radio business.
- **Exploiting "hidden assets."** Finding untapped capabilities to create alternatives—an MRO services company uses its internal demand-forecasting tools

to provide other companies' spare parts more rapidly.

- **Creative partnering.** Looking outside the industry to non-traditional sources of innovation. Consider Raytheon's adaptation of Google's Android platform as an experimental battlefield handheld device for soldiers.

So why are we not seeing more business model innovations take hold? Part of the reason is that launching one is not a natural act for most defense contractors. Managers are often conservative, more accustomed to decades-old standards for competing on new business—standards that are no longer affordable.

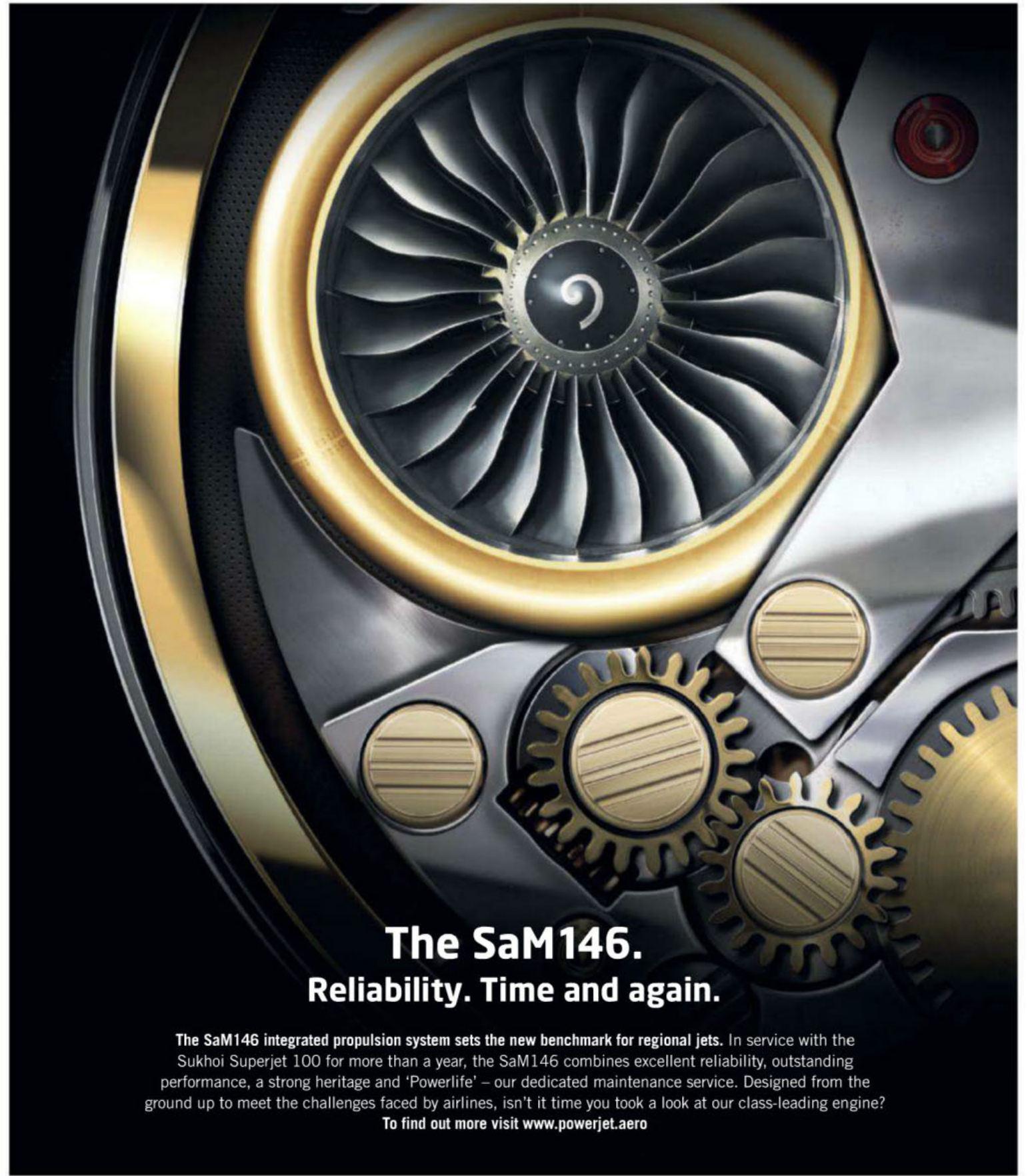
The business model successes we have studied or helped to implement all required significant change in business processes, management talent, capital allocation and governance. They often relied on a great deal of collaboration with trusted customers, because there were always hiccups along the way.

But contractor reticence is not the main challenge. The biggest barrier: government. At a time when the customer should be encouraging innovation, it is loading on new requirements, more auditing and tighter rules around competitions.

This should be a time when the government defines its most important mission needs and then asks contractors to provide innovative ideas. Let the contractors take on some of the inherent risk associated with business model innovation and reap the rewards if they deliver. For instance, if L-3 Communications can rapidly meet an airborne intelligence, surveillance and reconnaissance need using surplus aircraft, its shareholders should be rewarded. Of course, certain defense systems will not and should not ever be candidates for anything but the strictest developmental specifications and process standards. But that leaves a lot of room for innovation.

The path to more successful business model innovations mostly involves a change in mindset. Start with trust: Pursue market areas where suppliers and customers have an established business history and where joint interdependence exists. Take a few calculated risks. The government should encourage less of an audit-based culture. Contractors should find a few more uses for cash other than share buybacks. And think of it as talent development: At a time when both government and contractors are at risk of losing talent, deploying high-potential people to new business models is a great way to retain them.

Contractors need new avenues of growth, and the government needs a healthy industrial base. They both agree on the importance of partnering to find creative ways to fill unmet needs. What would happen if they opened up the aperture and let some new business models see the light of day? ☛

A detailed, close-up photograph of a jet engine's internal components. The central focus is the large, circular fan with numerous blades, surrounded by a golden-colored ring. Below the fan, several interlocking gears and smaller circular components are visible, all set against a dark, metallic background.

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