ATR's Battle With Used RJs **BEYOND BLACKWATER** What Is Erik Prince Up To? Combat Aircraft In Asia

# AVATORNATIONNEEK & SPACE TECHNOLOGY

# Has the U.S. Lost Its Lead In Hypersonics?





# **Digital Edition Copyright Notice**

The content contained in this digital edition ("Digital Material"), as well as its selection and arrangement, is owned by Penton. and its affiliated companies, licensors, and suppliers, and is protected by their respective copyright, trademark and other proprietary rights.

Upon payment of the subscription price, if applicable, you are hereby authorized to view, download, copy, and print Digital Material solely for your own personal, non-commercial use, provided that by doing any of the foregoing, you acknowledge that (i) you do not and will not acquire any ownership rights of any kind in the Digital Material or any portion thereof, (ii) you must preserve all copyright and other proprietary notices included in any downloaded Digital Material, and (iii) you must comply in all respects with the use restrictions set forth below and in the Penton Privacy Policy and the Penton Terms of Use (the "Use Restrictions"), each of which is hereby incorporated by reference. Any use not in accordance with, and any failure to comply fully with, the Use Restrictions is expressly prohibited by law, and may result in severe civil and criminal penalties. Violators will be prosecuted to the maximum possible extent.

You may not modify, publish, license, transmit (including by way of email, facsimile or other electronic means), transfer, sell, reproduce (including by copying or posting on any network computer), create derivative works from, display, store, or in any way exploit, broadcast, disseminate or distribute, in any format or media of any kind, any of the Digital Material, in whole or in part, without the express prior written consent of Penton. To request content for commercial use or Penton's approval of any other restricted activity described above, please contact the Reprints Department at (877) 652-5295. Without in any way limiting the foregoing, you may not use spiders, robots, data mining techniques or other automated techniques to catalog, download or otherwise reproduce, store or distribute any Digital Material.

NEITHER PENTON NOR ANY THIRD PARTY CONTENT PROVIDER OR THEIR AGENTS SHALL BE LIABLE FOR ANY ACT, DIRECT OR INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF OR ACCESS TO ANY DIGITAL MATERIAL, AND/OR ANY INFORMATION CONTAINED THEREIN. ULTRA-LIGHTWEIGHT, NEXT GENERATION ALUMINUM-LITHIUM STRUCTURE

> ORGANIC BODY SHAPE

TITANIUM-ALUMINIDE PROPULSION COMPONENTS



# Where the Future Takes Shape

Few people get to witness the course of history being altered. We've had a hand in steering it since the dawn of flight, the birth of highways, and the race to space. When our customers want to develop the next generation of iconic innovations, they look to us for the breakthrough materials and technologies that bring them to life. Because we haven't come this far to only come this far.

Arconic. Where the future takes shape.

Copyright © 2016 Arconic

**Contents** 

AVIATIONWEEK

Volume 179 Number 4

Winner 2016

**JESSE H**.

AWARDS

NEAL

Est. 1955



**Digital Extras** Access exclusive online features from articles accompanied by this icon.

- 7 Feedback
- 8 Who's Where
- 10-11 First Take
  - 12 Up Front
  - **13** Going Concerns
  - **14** Inside Business Aviation
  - **16** Airline Intel
  - **17** Leading Edge
  - 18 In Orbit
  - **19** Washington Outlook
  - 63 Classified
  - 64 Contact Us
  - 65 Aerospace Calendar

## **HYPERSONICS**

**20** National Academies report indicates U.S. may be losing its lead in hypersonics weaponry

## **COMMERCIAL AVIATION**



**24** Boeing enters busiest phase yet of 737 MAX development plan, with -9 rollout, -8 certification

- 26 Alaska Airlines addresses fleet strategy as it works through integration of Virgin America
- **28 Europe's airlines,** old and new, revise tactics to cope with sagging profits, intensifying competition

**ON THE COVER** 





These 20 outstanding undergraduate or master's degree students in aeropace engineering and related fields are poised to become leaders in research and industry.

- **38** Low fuel prices, leasing overcapacity and stronger U.S. dollar boost turbofan competition for ATR
- **39** China Eastern is adding more aircraft at Shanghai as China Southern eyes new Beijing airport

## DEFENSE

- **30 Boeing pitches** upgraded F-18 "Block 3" Super Hornet to optimize U.S. Navy's integrated network
- **32** Shockingly low U.S. combat aircraft readiness levels are noted to Congress by armed services
- **41 Saudi Arabia** starts inducting potent F-15SA Eagles after Boeing resolves flight-test issues



Are China and Russia threatening the U.S. lead in hypersonic propulsion? Guy Norris reports (see page 20). Cover concept by Aviation Week art department. Also in this issue: Why ATR thinks its turboprops can beat regional jets (page 38) | Blackwater founder on smarter defense spending (page 34) | Special report: combat aircraft in Asia (page 48)

Aviation Week publishes a digital edition every week. Read it at AviationWeek.com/awst and on our app.

**42 Kratos Defense** is developing combat drones for Air Force Research Laboratory and DARPA



## **FACE TO FACE**

**34 Blackwater founder discusses** his new China-facing transport services company and U.S. military

## UMANNED AVIATION

**37 European Union** lawmakers try to accelerate passage of harmonized regulations for civil UAVs

# Contents

## MANUFACTURING

**40** Turbofan structures are targeted for 3-D-printed composites by Oxford Perfomance Materials

41

## **NAVAL AVIATION**

**44 Beijing signals** its aircraft carrier plans with a mockup of an airborne early warning aicraft



- **46 Contenders from** Leonardo, Sikorsky and NH Industries line up for Seoul's maritime order
- **47 The Pentagon wants** an unmanned refueling capability to extend range of its aircraft carrier air wing

## **COMBAT AIRCRAFT IN ASIA**

- **48** India's air force and navy fighter needs present an eye-catching opportunity for aircraft makers
- **50** Proliferation of fighter types and versions frustrates China's air force and navy, snarls logistics

- **52 Chinese-Pakistani JF-17** Thunder fighter will fly this year, with new capabilities being added rapidly
- **53** Israel's Elta assists with radar and could have broader development role on South Korea's KF-X fighter

## **20 TWENTIES**

**54** Accomplished students distinguish themselves in aerospace research and projects in the world at large

### **AIR TRAFFIC CONTROL**

**60** Reconfigurable FAA voice-overinternet-protocol communications system enters testing

## ROTORCRAFT

**62** Safran studies hybrid power systems to reduce turbine engine size and lower fuel burn



## VIEWPOINT

**66** U.S. is risking its aviation advantage, stuck in 20th-century bureaucratic policies, processes





# Mobile. Online. Updated Daily.

Free to subscribers. Get new content daily and read the weekly digital edition of Aviation Week online or in our app.

#### DESKTOP/LAPTOP Go to AviationWeek.com/awst

#### **APPLE APP**

Go to the Apple App Store, search for "Aviation Week" and download the *Aviation Week & Space Technology* app to your iPad or iPhone.

#### **ANDROID APP**

Go to Google Play, search for "Aviation Week" and download the *Aviation Week* & *Space Technology* app for your Android phone or tablet.

#### LOGIN

Tap on any locked article to get to the login screen OR on the menu icon in the upper right corner of the app screen (image with three parallel lines) and tap "Login." Log in using the email address associated with your subscription.

**Forgot Password?** Tap the "forgot password" link on the login screen and follow the reset instructions emailed to you (this password may not be the same as your digital edition password).

**Customer Service** If you don't have a registered email or password, or are having problems with the download or login, contact our customer care team for assistance:

> Toll-free (North America) 800-525-5003

Outside North America (+1) 847-763-9147

Email: awstcustserv@halldata.com Web: AviationWeek.com/awstcustomers



# Data & Intelligence Solutions For The Defense Community



Each year, Aviation Week Network's editorial experts and data analysts produce our annual Aerospace & Defense issue. However, our coverage and data solutions go well beyond a single issue.

**From daily intelligence briefings** to fleet and forecast data to expert analysis of current and upcoming defense technologies, Aviation Week Network's suite of defense solutions gives you a strategic edge.

Leverage our data and intelligence solutions to make informed decisions, plan strategy, and locate and capture business. Go to: aviationweek.com/defensesolutions

# SpeedNews'

Market & Production Forecasts and Industry Briefings

# **7th Annual**

Aerospace Raw Materials & Manufacturers Supply Chain Conference



# March 13, 2017

Beverly Wilshire • Beverly Hills, CA

In conjunction with SpeedNews' 31st Annual Commercial Aviation Industry Suppliers Conference

#### **#SNRMC**

**31st Annual** Commercial Aviation Industry Suppliers Conference

# March 13-15, 2017

Beverly Wilshire • Beverly Hills, CA

#### **#SNASC**

#### SpeedNews

11500 W. Olympic Blvd., Suite 574 • Los Angeles, CA 90064, USA Tel: +1-424-465-6501 • Email: jspeed@speednews.com

Registration is open for both Conferences

Please visit www.SpeedNews.com or call +1-424-465-6501 for more information.

AVIATION WEEK

Powered by Penton<sup>\*</sup>

# AVIATION WEEK

Editor-In-Chief Joseph C. Anselmo joe.anselmo@aviationweek.com

Executive Editor James R. Asker asker@aviationweek.com

Managing Editors Jen DiMascio (Defense and Space) jen.dimascio@aviationweek.com

Jens Flottau (Commercial Aviation) jens.flottau@aviationweek.co.uk Graham Warwick (Technology)

graham.warwick@aviationweek.com Associate Managing Editor Andrea Hollowell

Art Director Lisa Caputo Editors Michael Bruno, John Croft, James Drew, Thierry Dubois, William Garvey, Frank Morring, Jr., Jefferson Morris, Guy Norris, Tony Osborne, Bradley Perrett, James Pozzi, Adrian Schofield, Lara Seligman, Lee Ann Shay

Artists Scott Marshall, Colin Throm Copy Editors Dan Hockensmith, Richard Leyshon, Arturo Mora, Patricia Parmalee, Andy Savoie

Production Editor Bridget Horan Aircraft Evaluation Editor Fred George

Contributing Photographer Joseph Pries

AviationWeek.com Director, Editorial and Online Production Michael O. Lavitt Director, Digital Content Strategy Rupa Haria Digital Content Marketing Manager Regina Kenney Digital Content Producer Jen Deglmann

**Editorial Offices** 

1166 Avenue of the Americas, New York, NY. 10036 Phone: +1 (212) 204-4200 1911 Fort Myer Drive, Arlington, Va. 22209 Phone: +1 (703) 997-0333

Bureaus

#### Auckland

Bureau Chief Adrian Schofield avweekscho@gmail.com

Beijing Bureau Chief Bradley Perrett bradley.perrett@aviationweek.co.uk

Boston Bureau Chief Kristin Majcher kristin.majcher@aviationweek.com

Chicago Bureau Chief Lee Ann Shay leeann.shay@aviationweek.com

Frankfurt Bureau Chief Jens Flottau jens.flottau@aviationweek.co.uk

Houston Bureau Chief Mark Carreau mark.carreau@gmail.com

Kuala Lumpur Bureau Chief Marhalim Abas marhalim68@gmail.com

London Bureau Chief Tony Osborne tony.osborne@aviationweek.co.uk

Los Angeles Bureau Chief Guy Norris guy.norris@aviationweek.com

Lyon Bureau Chief Thierry Dubois thierry.dubois@aviationweek.com

Moscow Bureau Chief Maxim Pyadushkin mpyadushkin@gmail.com

New Delhi Bureau Chief Jay Menon jaymenon68@gmail.com

Paris Bureau Chief Helen Massy-Beresford helen.massy-beresford@aviationweek.co.uk

San Francisco Bureau Chief Madhu Unnikrishnan madhu.unnikrishnan@aviationweek.com

> Washington Bureau Chief James R. Asker asker@aviationweek.com

Wichita Bureau Chief Molly McMillin molly.mcmillin@aviationweek.com

Gregory Hamilton President, Aviation Week Network

AVIATION WEEK NETWORK Powered by Penton<sup>®</sup> Penton is an Informa business

# **Feedback**

#### **PERSON TO PERSON**

I was pleased to see your selection of Ash Carter, Robert Work and Frank Kendall for 2016 Persons of the Year (*Jan. 9-22, p. 28*). But why were they not recognized earlier? Years ago when I was working at Delta Air Lines, I was shocked to see United CEO Jeff Smisek named as the *Aviation Week & Space Technology* Person of the Year for 2010 (*Jan. 3, 2011, p. 42*).

In that year it felt like Carter's name appeared in one out of every four articles, so why choose Smisek—noting the selection was predicated on future potential, not past accomplishment or influence: "While it is still too early to predict the full ramifications of this merger, the combination of United and Continental is a pivotal event in global aviation."

If anything, this award felt similar to then-relatively new-to-the-job President Barack Obama receiving the Nobel Peace Prize for great ideas two years earlier.

Overall, I was pleased to see Delta Air Lines CEO Richard Anderson as your choice in 2015 (*Dec. 21, 2015-Jan. 3, 2016, p. 31*) (in retrospect, correcting the 2010 misjudgment), and certainly agree with Russian President Vladimir Putin's "notorious" nod for 2014 (*Jan. 15-Feb. 1, p. 36*), and now it is good to see Carter and his cadre receiving this recognition, albeit belatedly. Please keep the well-considered selection of recipients of recent years coming. *Name Withheld by Request* CHICAGO, ILLINOIS

#### THE NATURE OF THE BEAST

Reader Dale Gibby penned an impassioned letter concerning President Donald Trump's "Twisted Logic" that gives me some pause (*Feb. 6-19, p. 7*). Does Trump sometimes utter or tweet conflicting, vague responses? Perhaps, and who knows why. What puzzles me more though is Gibby's view that mankind is essentially good, and it is the weapons that corrupt him. Empirically, the evidence doesn't support this.

Mankind seems to be flawed; to look elsewhere for the blame is not to be fully honest about our true condition. If we beat our swords into plowshares, I'm not convinced the Russians would follow, nor anyone else for that matter. Even if peace were to be achieved, it would be short lived; history proves this without fail. I do have hope, but it does not rest in man's "inherent goodness." *Matt Marohn* MAPLE LAKE, MINNESOTA

#### **GOING AND COMING AROUND**

Dale Gibby seems to have forgotten that President Barack Obama managed to communicate to Vladimir Putin that he would be able to be more flexible in dealing with the Russian president in his second term, and Obama's secretary of State, Hillary Clinton, had a "reset" with the foreign leader as well. *Larry Violette* 

REHOBOTH, MASSACHUSETTS



#### WEIGHT PENALTY?

I am surprised that there has been no feedback regarding Guy Norris's "Breaking Boundaries" (*Jan. 9-22, p. 51*).

Boundary-layer-ingestion fan testing at NASA Glenn Research Center's wind tunnel is an interesting fuel-saving experiment, but will it hold up over time on future aircraft engines?

For every revolution, a two-pulse in-and-out boundary (layer) intermittent airflow disruption will stress each fan blade, compressor blade and stator vane. Unstable airflow will cascade through the compressor section in all phases of operation. Such exposure promotes compressor stalling, extensive damage and inflight shutdowns.

Beefing up future compressors to withstand this exposure will require heavy compressor modules for expected engine longevity. This weight gain could defeat the fuel savings.

I commend the research innovators'

Address letters to the Executive Editor, Aviation Week & Space Technology, 1911 Fort Myer Drive, Suite 600, Arlington, Va. 22209 or send via email to:

#### awstletters@aviationweek.com

Letters may be edited for length and clarity; a verifiable address and daytime telephone number are required.

fuel-savings work on a single fan disk but feel that the compressor airflow drivers will be compromised. *Chris Barnes* CHARLESTON, SOUTH CAROLINA

# Online, *daves*787@*comcast.net* **wonders:**

What would happen if the boundary layer was just ducted under the engine as bypass air?

#### **PRESERVE AND PROTECT**

Thanks for Thierry Dubois's article "Invigorating Old Drawings" about ATR converting 1980s design blueprints to digital mockups (*Feb. 6-19, p. 35*). It's a good idea. The Defense Department should do the same.

The A-10 Thunderbolt II (Warthog) drawings should be digitized, as should the OVO-10 Bronco, if not by the Defense Department, then by the Library of Congress.

Each of these out-of-production aircraft are still in use and unsurpassed for close air support. Any future production or depot (MRO) actions, would have an advantage if such computer-stored data were available. If justification is required, just point to ATR and Stelia Aerospace as examples. I am sure the F-35 in its three variations is digitized. *Peter J. Peirano* RIDGEWOOD, NEW JERSEY

#### online poster Mark Lincoln observes:

I bemoan the sense of proportion students today do not receive from having to use a slide rule to estimate numbers. But I cannot deny the precision a calculator provides.... However, I had little nostalgia for the drafting board and parchment paper while doing technical drawing in Adobe Illustrator 88.

Bring on the digital mockup. Switch on real-time 3-D virtual-reality training.

#### SE Jones responds:

Virtual reality may make sense for you. Me? I prefer to board an aircraft and go, cramped seats be damned.

# Who's Where

orthrop Grumman Corp. has promoted Stan Crow (see photo) to chief executive for Japan from director of business development of directed energy. Crow had been a McKinsey and Co. technology, aerospace and defense consultant.

Robert J. LaBelle has been hired as CEO of XTI Aircraft Co. He had been CEO of AgustaWestland North America and president of AgustaWestland Tiltrotor.

Honevwell has named Stephen Gold vice president/general manager of connected enterprises. Gold had been IBM Watson Group's chief marketing officer/vice president of business development, overseeing partner programs, investments and mergers and acquisitions.

Katharine Morgan (see photo) has been promoted to president of ASTM International from executive vice president. She sits on the boards of the American National Standards Institute, the Council of Engineering and Scientific Executives and the International Consumer Product Health and Safety Organization, among others.

Jazeera Airways has named Rohit Ramachandran (see photo) chief executive officer. Ramachandran, a 20year industry veteran, has worked at KLM Royal Dutch Airlines, Singapore Airlines and Air Arabia and its subsidiaries, for which he managed the commercial organization.

Daniel White has been named executive vice president of satellite management services for the Americas at Swedish Space Corp. He will oversee national security, civil and commercial space business operations and customer relationships in North

and Latin America. White had worked for Hughes Space and Communications, Boeing and Lockheed Martin.

Quantum Research Interna*tional*, a technology services and product integration provider, has hired James Lackey as senior vice president of defense systems. Lackey had been a senior executive with the Defense Department.

Brian Hahn has been hired as vice president of flight services and Casey Norman as safety and compliance manager at *Elliott Aviation*. Hahn had been North Central Aviation operations director; Norman has 37 years of aviation experience.

L3 Technologies has appointed **Richard Foster** corporate vice president of Canadian operations, based in Ottawa.

Pemco World Air Services has promoted John Wing to senior maintenance, repair and overhaul manager from program manager. He will oversee all maintenance operations as well as business development and regulatory liaison including with the FAA.

Triumph Group has hired 30- S. K. de Beaupuy year aerospace veteran Gary **Tenison** as vice president of business development. Tenison had been vice president of marketing/business development at Kaman Aerospace Corp.

**Drew McEwen** (see photo) has been named vice president of international and direct sales at Piper Aircraft Inc.

CommutAir has named Adam



Stan Crow



Katharine Morgan



R. Ramachandran



Drew McEwen



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

Kline chief pilot of its recently opened Embraer ERJ 145 base at Newark Liberty International Airport in New Jersey.

#### HONORS AND ELECTIONS

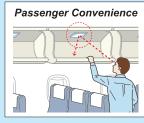
Christian Unrath has been appointed chairman of the Airbus Group Bank managing board. Unrath oversaw Airbus's acquisition of the bank, formerly the Salzburg Munchen Bank. He succeeds Norbert Kickum.

Alstom has elected as a director Sylvie Kande de Beaupuy (see photo), Airbus Group compliance officer and executive vice president of group ethics. She will serve on the Ethics, Compliance and Sustainability Committee.

Institutional Investor magazine has named HEICO Corp.'s Chairman/CEO Laurans A. Mendelson best CEO in the aerospace and defense electronics sector.

Aircraft lessor Avolon has appointed three nonexecutive directors: Ciaran O'Hogartaigh, who serves on Ireland's department of finance audit committee; Joe Nellis, once a GE Capital managing director of business development; and Denis Kalscheur, a former Aviation Capital Group vice chairman/CEO.

# the first in the world KomyMirror for Stowage Bins PAT.







- · Wide Field of View with Flat Surface
- Approved by AIRBUS & BOEING
- FAA/EASA Flammability Test Report Available Obtained AS9100

Komy Co., Ltd. KomyMirror Search If www.facebook.com/komymirror

# NOW'S THE PERFECT TIME TO EXTEND YOUR SUCCESS.

**777-300ER. A BETTER WAY TO FLY.** The Boeing 777-300ER's unique combination of superior range, outstanding fuel efficiency and passenger-preferred comfort has created long-range success for carriers around the world. And with recent upgrades that further reduce costs and boost revenue, now's the perfect time to add to that success, in the air and on the bottom line. The 777-300ER makes every fleet a more profitable fleet. That's a better way to fly.

mannin



1 Q.000

unn m mun

boeing.com/777

# **First Take**

#### **COMMERCIAL AVIATION**



UNITED AIRCRAFT CORP.

**Ilyushin and United Aircraft Corp. are to modernize Russia's Il-96** widebody airliner. Stretched by 31.7 ft. over the Il-96-300 to accommodate 390 passengers, the Il-96-400M will have improved Aviadvigitel PS-90A1 engines and updated avionics. To be produced by Voronezh Aircraft, first flight is planned for 2019.

**Singapore Airlines plans to buy 20 Boeing 777-9s and add 19 787-10s** to its previous launch order for 30, with options for six more of each type. The commitment is valued at \$13.8 billion at list prices. The Rolls-Royce-powered 787s will be delivered beginning in 2020 and the GE-powered 777s in 2021.

The European Commission wants to continue excluding flights to and from non-European countries from its Emissions Trading Scheme (ETS) now that an international agreement on carbon offsetting is to take effect in 2021. The "stop-the-clock" provision limiting ETS to intra-European flights expired at the end of 2016.

**Canada's federal government is providing Bombardier** with C\$327.5 million (\$285 million) in repayable loans, one-third for the C Series airliner and the rest for the Global 7000 business jet. Brazil has demanded talks with Canada at the World Trade Organization over government support for Bombardier.

**India's National Aerospace Laboratory is hoping to revive** its Saras twin-turboprop light transport. One of two prototypes built in the early 2000s is being prepared for flight evaluation. The goal is to produce the 14-passenger aircraft for the Indian air force and develop a 19-seat version for the commercial market.

## Lockheed Martin rolled out the first

## **DIED:** SATELLITE PIONEER HAROLD ROSEN

If not for **Harold Rosen**, satellite communications might still be a dream without a plan. Rosen (at left in photo), a brilliant engineer and skilled manager, pushed ideas that would become key to a communications revolution. He died at age 90 on Jan. 30 at his home in Pacific Palisades, California, from complications of a stroke.

Perhaps no one else is more responsible than Rosen for making the idea of satellite communication practical. One key was spin stabilization. Rosen refigured that spinning a spacecraft would it steady it

in space. But the antenna needed to point constantly. The solution was a "de-spun" platform that always pointed back toward Earth. Eventually, this led to the Hughes HS376, one of the most successful communications satellites of all time.

Satellite technology later went beyond spin-stabilization, but Rosen was still a driving force behind innovations. He oversaw the development of many satellites to follow at what was then part of Hughes Aircraft and is now a unit of Boeing.

Those who knew him said Rosen's team always felt comfortable with challenging him. "He always approached things from first principles. He wasn't swayed by what had been done before," says Dan Miller, a California venture capitalist who worked for Rosen in the 1980s.

After leaving aerospace, Rosen and his brother Ben founded a car company, Rosen Motors, to develop hybrid-electric vehicles.

Rosen won many awards, including an Aviation Week Laureate for lifetime achievement.

t displayed the Advanced Hawk, developed jointly with Hindustan Aeronautics Ltd., at the Aer

BAE Systems has

DEFENSE



BAE SYSTEMS

Ltd., at the Aero India show in Bengalaru. The aircraft has a slatted wing, more power, refueling probe, wide-area cockpit displays and smart weapons capability. The demonstrator will begin flight tests in India after the show.

LM-100J Super Hercules commercial

freighter version of the C-130J military

airlifter in Marietta, Georgia, on Feb. 9.

FAA certification and first deliveries to

the still-undisclosed launch customer

are planned for 2018. The aircraft is a

demilitarized long-body C-130J-30.

Taiwan is to develop an advanced

trainer, the XT-5, based on the AIDC

F-CK-1 indigenous fighter. A contract

Chung-Shan Institute of Science and

Technology. A prototype is expected

to fly in 2020, and 66 aircraft are to re-

place Taiwan's AT-3s and F-5s by 2026.

has been awarded to the National

Italy's Leonardo will still enter its T-100 version of the M-346 for the U.S. Air Force's T-X advanced trainer competition, but it will bid via its U.S. subsidiary DRS Technologies after its teaming agreement with Raytheon ended when the companies failed to reach a business arrangement.

Fairchild A-10s will remain in service with the U.S. Air Force to 2021 at the earliest, ending the years-long debate over the immediate future of the attack aircraft. Congress has blocked attempts to retire the aircraft—which are seeing significant combat use—to save money.



# For the latest, go to AviationWeek.com

The Raytheon/Mitsubishi SM-3 Block 2A surface-to-air missile developed jointly by the U.S. and Japan intercepted a medium-range ballistic



missile target on its Feb. 3 first launch from a destroyer in the Pacific. The beefed-up Block 2A will be fielded on Aegis warships and land sites beginning in 2018.

Unit price of the Lockheed Martin F-35 has dropped below \$100 million for the first time, with the Lot 10 contract for 90 aircraft. The conventional F-35A now costs \$94.6 million including engines and fees, a 7.3% reduction from Lot 9. The F-35B is \$122.8 million and F-35C \$121.8 million.

The U.S. has approved the sale to Kenya of up to 12 armed Air Tractor AT-802L counterinsurgency aircraft, plus two AT-504 trainers, in a deal valued at \$418 million. Prime contractor and integrator will be L3 Technologies.

Germany is to buy Kongsberg's Naval Strike Missile to arm its surface ships in a deal worth up to \$1.2 billion following Norway's decision to buy four Type 212 submarines from Germany's Thyssenkrupp Marine Systems.

#### SPACE



The Indian Space Research Organization orbited 104 satellites on one launch on Feb. 15, setting a world record. The Polar Satellite Launch Vehicle carried the Cartosat-2 satellite and 103 passenger spacecraft—including

88 Dove smallsats for Planet-on the flight from the Satish Dhawan Space Center.

## Orbital ATK has sued to halt

DARPA's Robotic Servicing of Geosynchronous Satellites program after the Pentagon research agency selected Space Systems Loral as its commercial partner for the on-orbit demonstration. Orbital argues that DARPA will subsidize a competitor to its Mission Extension Vehicle.

### ROTORCRAFT

Leonardo resumed flight testing of the AW609 civil tiltrotor, halted since the crash in October 2015, with the third prototype taking to the air in Philadelphia on Jan. 30 to begin icing testing. Certification is planned for 2018. The AW169 intermediate helicopter has received FAA certification.



LEONARDO Indonesian military police have impounded a Leonardo AW101 following its delivery to the air force, pending an investigation into its acquisition. Indonesian President Joko Widodo said in late 2016 he had canceled the contract, having terminated an earlier deal for three VIP AW101s.

Hindustan Aeronautics Ltd. displayed a full-scale mockup of the planned 12-metric-ton-class Indian Multi-Role Helicopter (IMRH) at the Aero India show in Bengalaru. Now in preliminary design, the twin-turbine IMRH will have a payload of 3,500 kg (7,700 lb.) and capacity for 24 troops.



# **<sup>4</sup>NASA** is clearly a priority for the president and his administration."

-Acting NASA Administrator Robert Lightfoot, ordering a study of what it will take to put astronauts on the first flight of the Orion crew vehicle around the Moon in response to President Donald Trump's inaugural promise to "unlock the mysteries of space."







## **100 YEARS AGO IN AVIATION WEEK**

Our Feb. 15, 1917, cover featured Orville Wright and Glenn L. Martin in front of the first airplane to fly, "the original Wright machine of 1903," which had been restored. Between them was the Michelin trophy, won by the late Wilbur Wright in France in 1908 for making a flight of 77 mi. in 2 hr. and 20 min. That issue's editorial warned that with the U.S. expected to enter World War I against Germany, the nation was ill prepared to

do battle in the air. "It is imperative that we should hasten the development of military airplanes for army and naval use, but there is little prospect that we should have such machines in any considerable quantities for some time to come," the magazine stated. Such concerns would prompt then-President Woodrow Wilson to order the establishment of the nation's first aeronautics laboratory—now NASA's Langley Research Center—later that year.

Read the complete Feb. 15, 1917, edition of Aviation & Aeronautical 🗦 🚍 Engineering at: archive.aviationweek.com

AviationWeek.com/awst

# **Up Front**





Contributing columnist Richard Aboulafia is vice president of analysis at Teal Group. He is based in Washington.

it amortizes the cost of developing its clean-sheet design, a question that is related to its expectation for total market size. Much of this nonrecurring expense is shared with Saab, but the Swedish company will want some degree of amortization,

too. If the development bill is \$1.5 billion, and this is amortized solely by the 350 aircraft in the T-X program, this represents a \$4.3 million additional cost for each aircraft. Since T-X unit costs will likely be lower than \$20 million, this added cost would be disastrous, particularly due to the RFP's risk cost-adjust-

ment. But if Boeing believes the total market is 1,000 aircraft, the unit cost increase would be in the \$1.5 million range, a far more manageable increment.

The problem is that the 1,000-unit market is speculative, at best. Boeing has designed an aircraft optimized for the T-X competition, and the world

market for supersonic high-end trainers is relatively small. There is also the light fighter market, but with its stadium seating and other trainer features, it is far from clear that Boeing's T-X can play a significant role as a light fighter. Even the T-50, sold as the FA-50 for light fighter missions, has only found a small export market niche. Selling 650 Boeing T-Xs for these missions in the world market would be a very difficult task.

Therefore, the big question is with Boeing. If it is sufficiently eager to win a new military airframe contract, it will make the aggressive decision to spread costs over a large and perhaps unrealistic number of aircraft, probably resulting in future losses. If it does not do this, then Lockheed/KAI will win, assuming the team puts in a sufficiently aggressive bid. It is Lockheed's to lose and Boeing's to win.

As for the Air Force, it has done its job, with T-X RFP terms harsh enough to eliminate two of the four frontrunners but reasonable enough to preserve competition between the two survivors. The service clearly has not left any money on the table. ©

COMMENTARY

# **Price Shootout**

# Why the T-X is Lockheed's to lose and Boeing's to win

ast month saw a sudden self-downselect by potential U.S. Air Force T-X trainer program contractors. Northrop Grumman, which had built a clean-sheet T-X prototype, decided it would not bid after all. Raytheon, bidding Leonardo's M-346 as the T-100, left the partnership, leaving Leonardo's expected bid as the sole non-U.S. prime.



On Jan. 1, there were four frontrunners, and two are now left. Lockheed Martin, offering Korea Aerospace Industries' T-50A, and Boeing, working on a clean-sheet design with Saab, will bid, perhaps along with Sierra Nevada Corp. Boeing and Lockheed Martin are sticking with the T-X, and they represent a study in contrasts.

The two dropouts left for a reason. The final T-X request for proposals (RFP), released in late December, basically constitutes a price shootout, not too different from the KC-X aerial refueling tanker competition. The RFP gives a price adjustment for superior performance but with a maximum that is less than \$400 million, for a contract valued at over \$16 billion. Improved maintenance costs do not count either, since there is merely a maximum life-cycle cost, with no credit for anything lower.

Meanwhile, T-X development cost overruns beyond a certain point will be borne by the contractor. The KC-X program used this formula too, resulting in Boeing's \$1.5 billion in KC-46 losses.

A contractor persisting in these



circumstances needs either an off-theshelf platform or a strategic imperative to win a U.S. military aircraft contract. Lockheed Martin has the former, while Boeing has the latter. Northrop Grumman, with a new aircraft and the important B-21 contract win behind it, had neither. Raytheon, which has not built an aircraft since it owned Hawker Beechcraft over a decade ago, had Leonardo's off-theshelf M-346, but it could not make the bid price numbers work.

While the T-50 and Boeing T-X will be superb performers, it will be hard for either to gain a performance edge, given the terms of the RFP. They both use the same GE F404 engine, and neither will be able to gain a significantly greater share of that performance incentivization increment than the other. For the Lockheed/KAI team, the advantage is in not having to bury any serious development costs in the bid price. As an off-the-shelf aircraft, the T-50 also will not suffer any risk-related upward price adjustment, another feature of the RFP with which Boeing will need to deal.

For Boeing, much depends on how

# **Going Concerns**

## COMMENTARY

# Middle of the Maelstrom

Activist investors target midtier A&D providers

**G**ordon Gekko may have been a fictional movie character, but increasingly he seems alive and well in the boardrooms of U.S. aerospace and defense (A&D) companies—and he could be aiming for a corner office near you, too.

While the make-believe activist investor from the 1987 and 2010 *Wall Street* movies—epitomized by the "Greed is good" sentiment—gave activists a bad reputation, today's real shareholders and stock traders often are more than happy when they target a company. Lately, they have been busy in A&D, particularly the midtier, and several analysts and consultants say it will only continue this year.

For instance, activist shareholder JANA Partners shook up Harris Corp. last summer when it took a stake and seats on the board of directors, leading Wall Street to expect divestitures to follow. On Jan. 27 Harris said it had reached a definitive agreement to sell its government IT services business for \$690 million to an affiliate of Veritas Capital, a major private equity investment firm. That follows another deal last November to sell its Cap-Rock Communications commercial business for \$425 million to Speed-Cast International.

Likewise, Arconic Chairman and CEO Klaus Kleinfeld probably was not planning to have to fight for his job this year. But Arconic, the Alcoa successor supplying A&D and automotive OEMs, and activist hedge fund Elliott Management are in the throes of a shareholder fight that will be determined this spring. The melee spilled into the open Jan. 31 when Elliott publicly pitched former Spirit AeroSystems CEO Larry Lawson to take over from Kleinfeld. Activists also are targeting major acquisitions, like Starboard Value questioning Rockwell Collins's move on B/E Aerospace and TCI Fund Management challenging Safran's pitch for Zodiac Aerospace.

These companies almost certainly will not be the last. In related but separate research, Moody's Investors Service says activists should prove busier in 2017 pursuing North American nonfinancial corporate targets, ostensibly including A&D providers.

Technology companies will be favorite targets, due to large cash accounts and low debt. But across industries, speculative-grade companies will likely be most targeted, the credit rating agency reported Feb. 2. That relates to their size, generally, and indeed Moody's says activists are expected to target mainly midsize and smaller companies, "with only occasional activity" at large ones.

"The bulk of activism will focus on smaller firms because it's easier to gain a foothold and exert leverage over their boards and management," Moody's says. "Smaller companies also have fewer resources to mount defenses against activist campaigns, in addition to being more plentiful relative to mid- and large-sized entities."

Other elements are in play, too, notes rival S&P Global Ratings. For starters, the new administration of President Donald Trump and Republican control of Congress have raised the prospect of corporate tax reform, with repatriation of U.S. corporations' foreign earnings expected to be a major goal.



Michael Bruno is Senior Business Editor Join the conversation at: AviationWeek.com/GoingConcerns michael.bruno@aviationweek.com

But this raises concerns over how public companies will balance the demands of shareholders and debtholders, the agency points out in a Feb. 13 report. Will companies limit purchasing of shares and use proceeds to repay some debt, or will they just "succumb" to pressure from activist investors and use most of the proceeds for shareholder-friendly activity, as happened during a similar 2004 tax holiday?

Finally, there is the fact that A&D public companies as a group could be in the midst of an interesting transition from "value" to "growth" stockswhether they are ready or not. As interest rates hit record lows in recent vears, federal budget restraints became weakened, and the commercial aircraft order cycle hit record highs, A&D companies enjoyed robust cash flows and could reward shareholders handsomely. Many did so, seemingly prioritizing shareholder returns over internal investments such as research and development (R&D) and even mergers and acquisitions (M&A).

"It almost feels like people got a little too carried away with the easy tactics of financial engineering versus positioning themselves," notes Hunter Hohlt, principal at PwC's Strategy& (formerly Booz & Co.).

Of course, that can last only so long—assuming stakeholders want the company to continue—and it attracts one kind of institutional investor, Hohlt tells Aviation Week. Those investors may take considerable persuasion when companies start recasting financial forecasts due to changing business conditions, let alone start maneuvering for long-term growth with more R&D and M&A.

Hohlt advises companies to get ahead of the activists, starting with communications to shareholders, and he cites another fictional movie character, professional assassin Martin Blank of *Grosse Pointe Blank*, to drive it home. In the 1997 action comedy, Blank rationalizes his job as a reaction to other conditions: "If I show up at your door, chances are you did something to bring me there," he says.

Says Holht, "If an activist shows up at your door, it's because you didn't do something." ©

#### **By Michael Bruno**

# **Inside Business Aviation**



COMMENTARY **Heavy Bet** 

# Cessna enters an unfamiliar starting gate

cometimes it's good to be late. For a gunfight, say, or embark-Ing on the Titanic. Or for the launch of the business jet era.

By the late 1960s, the JetStar, Sabreliner, Hawker 125, Jet Commander and 20-series Learjets were all firmly established in the marketplace and gaining. That's when Dwayne Wallace, Clyde Cessna's nephew and longtime head of the eponymous airplane company, finally decided the time was ripe for a Cessna general aviation jet.

By then, the Wichita manufacturer had a dozen years' experience manufacturing the T-37 "Tweet" twinjet trainer for the U.S. Air Force, and Pratt & Whitney Canada was developing the JT15D. Wallace thought the small turbofan would be ideal for his new model.

The FanJet 500 took to the air for the first time in September 1969. Initial reaction was mixed. The eightplace aircraft could operate out of short, general aviation fields, making it the turboprop competitor Wallace envisioned. But its fan engines—as opposed to turbojets-and straight wings made it a modest cruiser in comparison to other jets. Indeed, Lear salesmen mocked it as the "Nearjet" vulnerable to "bird strikes from the rear."

As development progressed, Wallace hired Jim Taylor, the man who successfully introduced Dassault's "Fan Jet Falcon" to North America, to market the new Cessna jet. Taylor and his team quickly renamed the aircraft the "Citation," hitching their slow steed to Calumet Farms' Triple Crown-winning thoroughbred. And they began pitching it directly-Taylor insisted the aircraft be sold and maintained by the factory, rather

than by distributors-to Cessna's broad base of customers.

Access to thousands of small airports, turbine reliability and quiet, and top-notch factory support combined to get the "Sensible Citation" sales moving. Within a year, Taylor predicted the company would sell 1,000 units-a figure greeted by snickers from its competitors at the time.

As of January 2017, Cessna had delivered more than 7,000 Citations, far more than other business jet manufacturers, many of whom have disappeared in the interim. And the Citation family continues to grow.

Over the decades, Cessna cleverly evolved the series—stretching some models, reengining others and sharing airfoils. In the doing, it came to dominate the light jet market, offering models ranging from the pocket-size, owner-flown Mustang to the twin Rolls-Royce-powered Citation X+, whose Mach  $0.935 M_{MO}$  makes it the world's fastest civil jet. Giddyap. So much for the "Slowtation" jibes.

However, being lengths ahead in the light- and medium-jet market hasn't been much comfort since the onset of the Great Recession. In 2008, Cessna delivered 466 Citations. For the past seven years, it hasn't delivered half that number, not even close, actually.

Rather than sit back and await market recovery, Textron Aviation-comprising Cessna and Beechcraft—is moving on up to a neighborhood populated by "heavy iron" jets, a category that has been more stable through the down economy. In 2015, the company's Latitude, a new model that falls within



3e William Garvey is Editor-in-Chief of Business & Commercial Aviation Join the conversation at: AviationWeek.com/IBA william.garvey@aviationweek.com

Citation's traditional markets, entered service. But eyes are now focused on the Longitude and Hemisphere, the largest Citation models since the Columbus project got canceled during the recession.

With max seating for 12, a fourpassenger range of 3,500 nm and powered by a pair of Honeywell HTF7700L turbofans, each producing 7600-lb. thrust, the \$23.9 million Longitude-now in flight testingslips neatly into the so-called supermidsize category. However, that field is already crowded with the Bombardier Challenger 350, Gulfstream G280, Embraer Legacy 500 and pricier Falcon 2000S, and new entrants are definitely unwelcome. It is to begin service later this year.

Further back is Hemisphere, expected to fly in 2019. With a threezone cabin, four-passenger range of 4,500 nm and an M<sub>MO</sub> of 0.90 Mach, it is seen by some, including business jet sales veteran Brant Dahlfors, as a successor to the Gulfstream G450, whose production ends next year to make way for the all-new G500. It will also compete with the 4,600-nm Falcon 900LX. However, priced initially at about \$35 million, the new fly-by-wire Citation, powered by Snecma Silvercrest engines, should be the value leader—by a lot—within its category.

While some question the ability of Citation's sales team to succeed against heavy iron veterans, Tim White, a former head of Cessna jet sales, does not. "These guys know how to compete," he says.

And as were the marketing targets for the original Citation, Cessna's vast user base will be earmarked for promotion of the company's newest ponies. "They have a fabulous step-up pool of clients, and most are very happy with Textron and Cessna," notes Rolland Vincent, an aviation consultant and market researcher based in Plano, Texas.

However, he predicts some Citation stalls will empty soon, with Mustang, Sovereign+ and X+ most likely to be put to pasture. "They've got too many."

Considering this stakes race will run for years, a stable full of winners seems, well, not so bad a problem.

# Advanced thermal management for extreme military environments

Around the globe, military and aerospace systems designers have turned to Meggitt to help them meet thermal and power management challenges with compact, lightweight, and efficient vapor cycle systems and liquid cooling sub-systems.

Meggitt has developed cooling solutions for the most challenging flight conditions, missions, and extreme environments.

From low supersonic flight, to high hot wet hover, to desert and arctic operations, our thermal management solutions are proven and ready to meet the challenge of the more electronic platform and battlefield.

**MEGGITT** smart engineering for extreme environments

Tel: +1 949 465 7700 E-mail: gerry.janicki@meggitt.com www.meggittdefense.com

# **Airline Intel**



Jens Flottau is Managing 📃 📃 Editor for Civil Aviation Join the conversation at: AviationWeek.com/AirlineIntel Jens.flottau@aviationweek.co.uk

O'Leary-not for the first timeraised another issue with more potential benefit. He believes it is inevitable that European LCCs will feed their legacy rivals. Though alliances between LCCs have been made in Asia, they probably will not be a major trend in Europe. LCCs feeding legacy carriers has not really happened much, and where it has been tried—in Malaysia between AirAsia and Malaysia Airlines—it was a big failure. But it is more likely than not going to take place in Europe.

The reason is simple: Legacy carriers have not found ways to lower costs for feed enough and have faced the issue in different ways. British Airways is not focusing on European feed anymore for its London Heathrow hub. Iberia has become selective in terms of where it generates feed. Lufthansa is trying to still fly the hub routes itself, but it has to accept major margin dilution. It is concerned about inflicting damage on its brand if that part of its business is outsourced, though at some point the pain may just be too much to bear. And Air France does not seem to be making much progress in improving the efficiency of its Paris hub.

The brand argument appears to be outdated. Passengers have long been acquainted with LCCs; their growth into prevalence as the short-haul business model has ensured travelers know what to expect or not expect. And many legacy carriers have picked up product features introduced by LCCs for their own offerings. No one is surprised anymore that inflight food is no longer free or that checked bags cost extra. Seat pitch is no longer a differentiating factor. Anyone doubting that should fly in Row 26 or so of Lufthansa's Airbus A320neo, where that added extra seat row eats into the personal space of passengers flying on the less expensive tickets.

Big legacy/LCC deals will happen over the next few years because they are in the interest of both sides. Feeder routes could be a new growth opportunity for the LCCs. As the market becomes more crowded and most of the obvious nonstop markets are occupied, other options are necessary. The pain will be shared.

# COMMENTARY What Alliances? RYANAL ................ JOEPRIESAVIATION.NET

# European LCCs are likely to cooperate with legacy airlines, but perhaps not with one another

Syanair CEO Michael O'Leary and Norwegian CEO Bjoern Kjos, attending the Airlines for Europe (A4E) Aviation Summit in Brussels in February, were repeatedly asked when and how they would somehow link their networks. The notion behind the question is that something really huge and, for competitors, very scary is about to emerge in European air travel.

While significant ongoing structural changes in the industry cannot be denied, broad alliances among European low-cost carriers (LCC) will not likely be a major theme, except in specific circumstances. Europe's low-cost industry is already highly consolidated, with Ryanair, EasyJet, Vueling and Wizz Air the dominant forces. Lufthansa's Eurowings division is growing fast and probably will soon be the third-largest carrier, although it is debatable whether it is an LCC or a hybrid lower-cost direct-services operation. Unlike in Asia, where two low-cost alliances have been formed, market access is not an issue. And Europe's LCCs are much larger than the many smaller players that have formed the Asian alliances.

Market structure and traffic rights are not the only factors. The industry, and Ryanair in particular, is still very reluctant to add cost. Norwegian and Ryanair have been talking about their proposed feeder deal, but so far the work required to make the information technology systems communicate has slowed progress. When cooperation eventually starts, Ryanair envisions minimum connecting times of 3 hr. to ensure that as few passengers as possible ever miss their next flight.

That condition alone makes such an alliance highly unattractive from a passenger's point of view. Who wants to wait 3-4 hr. to connect between short intra-European flights? Even for a long-haul connection to the U.S., such a long transition is inconvenient. Many passengers will find much better flight pairs on WOW Air or Icelandair, or they may even be willing to pay more for a seat on a legacy airline if their convenience is much enhanced.

There are not that many airports where transit deals make sense. The airport has to be a large base for the short-haul carrier but not for the airline operating the long-haul leg. If it had its own intra-European network at the base, there would be no need to seek alternatives. There are also only a limited number of cities that justify long-haul services, even at low fares. Ticking all of these boxes will offer up some interesting markets, but not so many that it justifies the ongoing debate.

# **Leading Edge**



E Graham Warwick is Managing Editor for Technology Join the conversation at: AviationWeek.com/LE warwick@aviationweek.com

## COMMENTARY

# **Vision to Reality**

At Uber, former NASA electric-aircraft evangelist will get a chance to bring vertical-lift air-taxi vision to fruition

ark Moore is a man with a mission. For 32 years an aeronautical engineer at NASA Langley Research Center, he has joined Uber as engineering director for aviation, working to enable the ride-hailing giant's vision of highly automated, electric-powered air taxis lifting passengers over congested roads.

At NASA. Moore was an evangelist for distributed electric propulsion and advanced verticaltakeoff-and-landing (VTOL) concepts. He became the agency's chief technologist for ondemand mobility, seeing in the convergence of electric propulsion and vertical lift the creation of a new aviation market.

At Uber, Moore (see photo) will work with Chief Product Officer

Jeff Holden to advance the concept of urban vertical-lift ride-sharing articulated in a white paper released last October. Moore consulted on the paper, which details not only Uber's operating concept, but also its requirements for the VTOL aircraft and ecosystem.

Uber's vision, and those of other entrepreneurial companies eyeing the on-demand aviation market, is heavily influenced by Moore's conceptual design work at NASA. This ranges from the Puffin single-seat electric tailsitter VTOL personal air vehicle unveiled in 2010 to the X-57 Maxwell distributed electric propulsion flight demonstrator that NASA plans to fly by 2018.

Uber plans to buy and operate the electric air taxis, not manufacture them. The research and technology links Moore has developed at NASA with the nascent electric aircraft industry will be an important part of the company's plans to encourage development of an industrial base that



can meet its needs for high volume and low cost.

Moore's work has connected NASA to several Silicon Valley startups. These include Joby Aviation, which is developing the electric motors for the X-57 while building a proof-of-concept prototype of its S4 four-seat electric VTOL aircraft, which has six tilting props mounted on the wing and tail. Another is design house ESAero, prime contractor for the X-57. NASA has funded LaunchPoint Technologies' development of high powerdensity electric motors and Metis Design's small turbogenerators for hybrid powertrains.

Moore's concepts are also credited with inspiring Google co-founder Larry Page to fund not one, but two startups working secretively on electric VTOL aircraft: Zee.aero, whose multirotor design has been seen in hover tests, and Kitty Hawk, said to be working on an aircraft resembling a scaled-up quadrotor drone.

With Mike Hirschberg, executive director of vertical-flight technical society AHS International, Moore has been instrumental in organizing transformative VTOL workshops to bring together U.S. and international players from the aerospace and automotive industries, and potential customers, in an effort to kickstart the on-demand mobility market. "No one has Mark's passion," says Hirschberg.

The energetic Moore has not been shy about criticizing NASA aeronautics from within for being risk-averse and focused on large commercial aircraft, and "barely involved" in emerging electric-enabled aviation markets, including atmospheric satellites and package-delivery drones as well as urban air taxis.

But his passion has helped bring changes. NASA's Convergent Aeronautics Solutions program has been created to explore the transformative potential of commercial technologies through rapid feasibility demonstrations. Moore's work also led to the X-57, NASA's first X-plane in over a decade and the precursor for a major research effort into electric and hybrid-electric propulsion for larger aircraft.

NASA's rotorcraft research, which has languished in recent years, has been restructured into the Revolutionary Vertical Lift Technology program and expanded to embrace electric VTOL technology for unmanned and manned aircraft-although the funding available is still extremely limited. It remains to be seen if NASA's renewed emphasis on X-planes can be extended to the vertical-flight segment.

When Uber released its verticallift ride-sharing white paper, Moore reacted enthusiastically. "The exciting thing about Uber getting involved in urban air-taxi is that they bring the big picture for creating feasibility for the entire transportation system," he said. "Uber is bringing a much-needed missing element—a company ready to buy these vehicles and focus on development of the required infrastructure and local approval processes." He now has a key role to play in making that vision a reality. 🐼

# In Orbit



Frank Morring, Jr. is Senior Space Editor Join the conversation at: AviationWeek.com/InOrbit morring@aviationweek.com

## COMMENTARY

# **Data Dump**

# U.S. milspace-sensor archives may ease space-weather risks to the wired world

The U.S. government is beginning to relax its reflexive hold on environmental information it has collected with nationalsecurity spacecraft, spurred by a growing awareness that today's worldwide web of power and data links is vulnerable to extreme

### space-weather events.

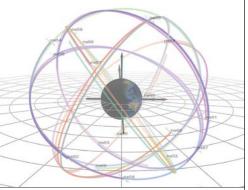
The recent release of 16 years' worth of space-radiation measurements collected by U.S. Air Force GPS birds likely will be supplemented with similar data collected by classified satellites under the terms of an executive order signed by former President Barack Obama last October.

"There are other national security assets that were very generally referred to in the executive order," says Marc Kippen of the Los Alamos National Laboratory. "We can't talk about the particular names of the satellites, but we are trying to release similar data from other national security assets."

Kippen manages the Los Alamos program that developed the radiation sensors on the nation's GPS satellites, which operate in mid Earth orbit (MEO) where radiation trapped by the planet's magnetic field—the Van Allen belts—is most intense. The charged particles there can wreak havoc with the microcircuitry that makes spacecraft computers and other avionics tick, but until recently the data collected by GPS was not available to most space-weather researchers.

"Today, 23 of the nation's more than 30 on-orbit GPS satellites carry these instruments," Kippen says. "When you multiply the number of satellites collecting data with the number of years they have been doing it, it totals more than 167 satellite years. It is really an unprecedented amount of information."

The sensors measure and record the energy and intensity of electrons, protons and other charged particles



LOS ALAMOS NATIONAL LABORATORY

in six orbital planes about 12,600 mi. above the surface (see illustration). The network records 92 measurements per day.

Two different sensors measure a wide range of energetic electrons and photons. The Combined X-ray Dosimeter instrument is mounted as a hosted payload on 21 GPS birds, and two more carry the Burst Detector Dosimeter for Block 2-R sensors.

Originally designed to help the Air Force gauge the effects of the space environment on spacecraft operations, the rich GPS historical dataset is likely to be of value to scientists studying how Earth's magnetic field interacts with the solar wind and to engineers developing radiation-hardened avionics to extend the total ionizing dose spacecraft can withstand over a service life of 15 years or more.

"We really do like to see this data, so that if we are selling product in a particular orbital regime we can tell the customers what life expectancy they will get out of our product, or how they might want to shield it. In our design for certain products we may make some design tweaks to provide a little more tolerance for those levels of radiation," says David Rea, director of space technology processing systems at BAE Electronic Systems.

As more satellite owners opt for using solar-electric propulsion to place their platforms in geostationary orbit, the avionics will be spending more time in the high-radiation regions of MEO as they inch their way upward. And it is conceivable that the technology for refueling and repairing operational spacecraft will increase the demand for longer avionic service life in space.

The GPS and other national security spacecraft data also may help spaceweather forecasters predict a much more serious possibility—a direct hit from a massive solar storm comparable to the one in 1859 that disabled the U.S. telegraph system. Known as the Carrington Event for the British astronomer who observed the coronal mass ejection that triggered it, a comparable event today could be devastating to the world's wired economy.

Obama's order directing the data release was entitled "Coordinating Efforts to Prepare the Nation for Space Weather Events." There is a growing awareness in government that the tightly interconnected global power and data networks are vulnerable to severe damage if a high-intensity solar storm scores a direct hit on Earth. Operators of power grids and satellites can take steps to mitigate the effects of the transient events, making predicting them a growing priority.

Los Alamos has a new project to predict the effects of a Carrington Event on the terrestrial power grid, according to Steve Morley, a researcher at the national lab. With the GPS data just released, a similar statistical approach could be used to predict the behavior of the MEO environment in a Carrington Event even though there has not been a direct hit in the space age.

"Having a wealth of data really lets you specify the range of variability of the environment a lot better, which gives you more confidence when you extrapolate to the very large events," Morley says.

## By Frank Morring, Jr.

## COMMENTARY

# **New Trajectory**

# Opportunity to bolster missile defense programs?

or more than a decade, Rep. Trent Franks (R-Ariz.) championed more funding for missile defense programs. Under President Barack Obama, the Missile Defense Agency's (MDA) allotment was cut.

Now it seems as though Franks's wish may come true. He scored a major symbolic victory last year, shifting the nation's missile defense policy from one that sought to produce a limited capability against a limited threat to one that seeks to maintain and improve a robust missile defense capable of defending the U.S. against a developing and increasingly complex threat.

With that foundation, and a Republican Congress and president supportive of missile defense, Franks sees the potential to restore the MDA's budget to levels not seen since President George W. Bush's administration—if not higher. "I understand it is going to be subordinated to a significant degree to budget realities, but the fact is, that is our trajectory," Franks says.

In Franks's view. Obama retreated. allowing Russia and China to advance technology in hypersonic glide vehicles and space-based weapons. Iran is looking to gain an asymmetric advantage using electromagnetic attack, potentially targeting the U.S. power grid. North Korea is not only making missiles with a longer reach but is also working toward smaller, less detectable weapons.

To make up for lost ground, Franks and other Republicans will seek additional funding for research on directed energy and space-based sensors. They want to develop an East Coast missile defense site, accelerate a Multiple Object Kill vehicle to counter decoys and equip Ground-Based Interceptors with a Configuration 3 booster that can counter new types of missiles.

**EXPLORING HUMANS** Acting NASA Administrator Robert Republicans are likely to place a priority on national missile defense

programs such as the Ground-based Midcourse Defense system.

Lightfoot, in coordination with the White House, has ordered the agency to study what it would take to put astronauts on the first flight of the Orion crew capsule around the Moon, a mission now slated for next year. While adding a crew would doubtless push back the launch date of "Exploration Mission One" (EM-1), Lightfoot told NASA staffers Feb. 16, "NASA is clearly a priority for the president and his administration.

"President [Donald] Trump said in his inaugural address that we will 'unlock the mysteries of space," Lightfoot wrote in a status report to staff. "Accordingly, it is imperative to the mission of this agency that we are successful in safely and effectively executing both the Space Launch System (SLS) and Orion programs."

NASA currently plans to send an unmanned Orion atop the first flight of the heavy-lift SLS into distant retrograde orbit around the Moon by the end of 2018 and is building hardware for that 25-day mission. EM-2, the first planned flight with a crew, is targeted for 2021.

Lightfoot stressed that the focus on SLS and Orion does not mean NASA will forgo its efforts to accelerate U.S. space activity by working with the private sector to expand commercial space opportunities. "The SLS and Orion missions, coupled with those promised from record levels of private investment in space, will help put NASA and America in a position to unlock those mysteries and to ensure this nation's world preeminence in exploring the cosmos," he stated, in reference to Trump's single mention of space in his Inaugural. 🛛

#### **READY TO RESPOND?**

In recent weeks, Russia has sailed a surveillance ship in international waters off the East Coast, sent military aircraft to buzz the USS Porter in the Black Sea and deployed a new SSC-X-8 cruise missile in defiance of an arms control treaty.

While members of Congress are calling for "immediate action" in response, President Trump's take on this is unclear. Although saving the incidents are "not good," he told reporters he did not think Russian President Vladimir Putin was testing him. Asked if these actions would damage the U.S.-Russian relationship, Trump said "No. We'll see what happens." And if he had a response in mind to Putin or North Korea, Trump said, he would not tell reporters about it.

Congressional Republicans have been raising questions about Russia's propensity to violate the Intermediate-Range Nuclear Forces Treaty since 2012. Rep. Mac Thornberry (R-Texas), chairman of the House Armed Services Committee, points out that Obama did little to respond. Thornberry's counterpart in the Senate, John McCain (R-Ariz.), says the U.S. needs to do more. "It is time for the new administration to take immediate action to enhance our deterrent posture in Europe and protect our allies." ©



# **Hyper Threat**

U.S. is losing momentum in hypersonic arms race as China, Russia catch up, says report

**Guy Norris Los Angeles** 

ess than four years ago, it seemed that the U.S. Air Force was on the brink of developing the first generation of air-breathing high-speed strike weapons following the success of the experimental scramjetpowered Boeing X-51A. Now a classified report warns that the U.S. may be losing its lead in hypersonics to China and Russia.

Although parallel research on hypersonic glide vehicles under DARPA's HTV-2 program suffered failures in 2010 and 2011, the Air Force by 2013 appeared enthusiastic about weaponizing the maturing air-breathing technology demonstrated in the X-51A flight tests. After more than five decades of development and testing in high-speed flight, the U.S. finally looked set to become the undisputed leader in hypersonics.

But as China and Russia demon-

strate dramatic strides in the technology, the U.S. is in danger of falling behind, warns a classified report by the National Academies of Sciences, Engineering and Medicine now being briefed to senior Pentagon officials. Unless greater urgency and cohesiveness are injected into this crucial area of defense technology, the report says, the U.S. will become vulnerable to the threat from a new class of superior high-speed maneuvering weapons.

#### The DARPA/Air Force HAWC program will not fly a scramjetpowered missile demonstrator until 2019, six years after the last X-51A flight.

The report, commissioned by the Air Force in early 2015, was published late last year and has already been reviewed by the Air Force Research Laboratory and defense acquisition officials. "The good news is that everyone who has seen it so far says it makes sense," says Mark Lewis, chairman of the National Academies' Committee on Future Air Force Needs for Defense Against High-Speed Weapon Systems, which produced the report.

"We are briefing it around town," adds Lewis, who explains

that although the committee's charter was to focus on defense, the report also discusses developing offensive capabilities for both a counter and a defensive response. "You really cannot talk about defensive capabilities without linking them to offensive components. We were not making recommendations on what the Air Force should do in terms of developing its own hypersonic systems per se, but embedded in the report is the notion

LOCKHEED MARTIN

# Key U.S. Hypersonic Vehicles, Tests and Projects

**1947** National Advisory Committee for Aeronautics 11-in. hypersonic research wind tunnel opens at Langley, Virginia.

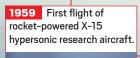
**1949** German V-2-boosted WAC Corporal rocket becomes first vehicle to exceed Mach 5.



**1956** Lockheed X-17 reentry test vehicle flight tests begin.



**1958** First hypersonic research wind tunnel opens at Arnold Engineering Development Complex, Tennessee.





that you need to have your own developmental efforts," he says.

The U.S. is currently pursuing two main hypersonic development paths led by DARPA, with the Air Force, aimed at flight tests by 2019. Under the first initiative, Lockheed Martin and Raytheon are working competitively on an air-launched, rocket-boosted and scramjet-powered successor to the X-51A dubbed the Hypersonic Airbreathing Weapon Concept (HAWC). The second path is the Tactical Boost Glide (TBG) program under which Lockheed Martin is developing an unpowered hypersonic vehicle that will detach from the air-launched rocket stage in the upper stratosphere and glide to its target.

Unlike a conventional ballistic-missile reentry vehicle, the hypersonic glide vehicle will be capable of aggres-

#### Notional artist's impression of China's DF-ZF hypersonic glide vehicle, which is boosted to its high cruise speed by a ballistic missile.

sive maneuvers on its run to the target, making interception by even such advanced surface-to-air missile systems as the recently tested Raytheon Standard Missile-3 Block IIA guided missile more difficult. In addition, because the weapon is injected at high speed into the stratosphere, anti-missile defense systems will have much less time to respond.

China and Russia are accelerating development of air-breathing and boost-glide hypersonic weapon systems, and both are believed to be targeting 2020 for deployment of the first operational units. The alarm at

1959 Launch of Boeing X-20 Dyna-Soar manned boost-glide vehicle project, not flown and canceled in 1963.
1959 U.S. Air Force Alpha Draco boostglide experimental test vehicle flight tests.

NATIONAL ARCHIVES

the Pentagon was first sounded in early 2014 when U.S. space-based sensors detected Chinese tests of a hypersonic glider boosted by a DF-21 mediumrange ballistic missile. Dubbed the DF-ZF by China and the WU-14 by the U.S, the vehicle has since been tested several times on a variety of both solidand liquid-fueled ballistic missiles.

In October 2015, it also emerged that China had successfully tested a scramjet-powered hypersonic vehicle when the project's leader, Wang Zhenguo, a professor at the National University of Defense Technology, was recognized for the achievement. advanced vehicle, the Yu-74, were observed in 2016. The newer vehicle was launched from Orenburg on an RS-18A ballistic missile and targeted at Russia's Kura test range in Kamchatka. The program's stated aim is development of conventional or nuclear-armed hypersonic glide warheads for the Makayevdesigned RS-28 Sarmat next-generation ICBM, which is due to enter service around the end of the decade.

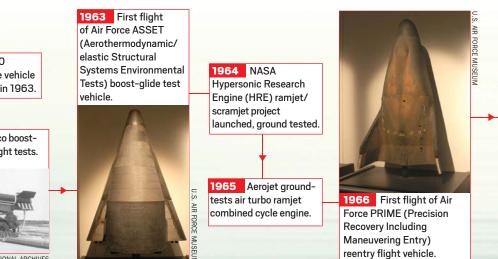
Although Russia has also researched and developed air-breathing hypersonic vehicles for many decades, including the Kh-90 (AS-19 Koala) high-speed cruise missile, it also appears to have



DANIEL TOSCHLAGER AND JAY MANTRI/WIKIMEDIA

Russia is developing a series of hypersonic glide vehicles under its Project 4202 weapons program. Initial flights of the experimental Yu-71 atop an SS-19 missile took place in 2015 from Dombarovsky missile base in Orenburg, close to the border with Kazakhstan in southern Russia. Tests of a more been making steady progress in tests of a variety of hydrogen-fueled scramjet-powered experimental waveridertype vehicles developed by the Gromov Flight Research Institute. The latest of these, the GLL-AP-02, is provisionally targeted for test flights in 2018-19.

In light of these advances, the Na-



#### **HYPERSONICS**

1968 Atlas-boosted Air Force Boost Glide Reentry Vehicle flight test.

1979 First test flight of Minuteman ICBM-boosted Advanced Maneuverable Reentry Vehicle, paving way for Sandia Winged Energetic Reentry Vehicle Experiment tests in 1980s and Advanced Hypersonic Weapon test in 2011.

1981 Space shuttle

first orbital flight and

hypersonic reentry.

1978 Air Force classified Advanced Manned Spaceflight Capability piloted-rocketplane program, later became TransAtmospheric Vehicle. Not flown; canceled in 1986.

tional Academy report warns that U.S. efforts, in contrast, appear to be losing momentum and focus. "We also wanted to communicate a sense of urgency," says Lewis. "Even the programs that we have underway do not seem to be demonstrating that sense. If HAWC flies when it is supposed to fly, that is 2019. That's almost a decade after the first flight of X-51. You hear things such as, 'We will develop in 2030, 2040.' For crying out loud, what's taking so long?"

But why the urgency? Other nations, says an unclassified, redacted version of the report, "have taken advantage of data and lessons learned from the U.S. and have been helped by the start-stop approach to technology development (including canceling programs even after major successes) and inefficiencies in the U.S. acquisition processes." As a result, the committee concluded, the U.S. "may be facing a threat from a new class of weapons that will effectively combine speed, maneuverability and altitude in ways that could challenge this nation's tenets of global vigilance, reach, and power."

"We pointed out that if you have maneuvering, high-speed systems available, you can now take on the world's greatest military with a lesser navy and a lesser air force," says Lewis. "You don't need to go ship-to-ship if you can hold the Navy at risk with a new weapon and can produce these effects without investing in a comparable military force. That was part of our warning to the Air Force as well." Referring to the greater long-range threat posed by these weapons, Lewis adds, "If we are forced to stay farther and farther away, it absolutely changes the way we do things."

NASA

Hypersonic development also needs to be focused and organized as a national priority, says the report. "The committee overall realized the programs just are not coherent. There are projects and concepts, but the field would benefit from more national-level direction," says Lewis. With technologies already well advanced, the report recommends that more leadership should be shown by the services, rather than leaving this role to research organizations such as DARPA. "The Air Force hasn't really taken ownership. One of the things we have been asking about is plans for an analysis of alternatives [AoA], so why isn't an AoA being done now?," says Lewis. We call this out in the report, but it is out of our scope to make that level of recommendation. We 1982 Start of classified DARPA Copper Canyon air-breathing single-stageto-orbit project, evolved into X-30 National Aerospace Plane in 1986. Not flown: canceled in 1990s with termination of follow-on Hypersonic Systems Technology Program in 1995.

also believe the Air Force should be doing its own experimentation." Others involved in U.S. hypersonics



DARPA

support the report's recommendations. Kevin Bowcutt, senior technical fellow and chief scientist for hypersonics at Boeing Research and Technology, says

2002 DARPA, Boeing, U.S. Navy Hypersonic Flight Demonstration (HyFly), a dual combustion ramjet-powered strike missile demonstrator program launched. Final test attempt failed in 2010.



2010 First orbital mission of Boeing-built Air Force X-37B spaceplane, derived from NASA/ DARPA X-37A.

2009 First experimental test flight of joint U.S.-Australian HiFiRE (Hypersonic International Flight Research Experimentation) fundamental research program.

2010 First launch of Boeing, Air Force, DARPA, NASA, Pratt & Whitney Rocketdyne scramjet-powered X-51A WaveRider. Achieved Mach 5.1 and 210 sec. of hypersonic flight on final flight in 2013.



2010 First unsuccessful flight of DARPA Falcon Hypersonic Test Vehicle 2 (HTV-2) intended to demonstrate prompt global strike capability at Mach 20. Second flight lost in 2011 due to aeroshell degradation.

2013 Lockheed Martin unveils Mach 6 SR-72 surveillance/strike concept aircraft to Aviation Week.

**1995** Orbital Sciences selected by NASA for X-34 orbital launch vehicle. Not flown; canceled in 2001.

> **1996** NASA begins X-33 single-stage-to-orbit rocketplane to be built by Lockheed Martin. Not flown; canceled in 2001.

"many lessons on the path to X-51A success were hard-earned. Given the criticality of hypersonics as articulated in the report and with X-51A under our belt, there would be obvious value in leveraging this extensive experience and know-how to accelerate full-scale development of an operational hypersonic vehicle or weapon."

Bowcutt also believes the U.S. needs to create "a comprehensive national plan with adequate funding that fields

#### Two flights of DARPA's HTV-2 highlift/drag hypersonic glider ended after 9 min. when the vehicles were lost after pull-up from reentry.

offensive and defensive hypersonic capabilities as quickly as technology maturation, system integration and capability demonstration allow."

"It is a big problem for us. We have been kind of resting on our laurels," says Leon McKinney, president of McKinney Associates and former executive director of the U.S. hypersonics industry team. "The U.S. has been fighting wars and terrorism, so that is one of the reasons why we have not seen a burst of capability developments. But it seems our adversaries are catching up." **2001** First flight of scramjet-powered X-43/Hyper-X. Second flight at Mach 7 in March 2004 marked first known operation of a scramjet in flight. Third flight in November 2004 attained Mach 9.6.



McKinney backs a three-phased approach to spurring development of a boost-glide capability, starting with a focus on an offensive hypersonic system that he believes could still be fielded within three years. Development of a defensive system, which McKinney says is "tough," would aim at characterizing Chinese and Russian vehicle maneuvering capabilities to produce a "threat tube," to enable effective interdiction. A third element would include development of a maneuvering target vehicle "which we could engage as a simulated threat."

The report does not specify that current programs should be abandoned, "but we think there are some programmatic changes we need to see," says Lewis. "We just say, step on the gas and move these programs forward. If you want to map out a strategy to get you from the things we have tested to an operational system, one would argue we are not on that track."

Check 6 Guy Norris and Graham Warwick discuss rapid advances by China and Russia and the slow pace of U.S. research: AviationWeek.com/podcast

**2016** DARPA launches Advanced Full-Range Engine program to demonstrate turbine-based combined cycle-system for hypersonic aircraft, building on previous Mode Transition and Falcon Combined-cycle Engine Technology efforts, the latter completed in 2009.

2016 Lockheed Martin and Raytheon win contracts to compete for DARPA/ Air Force Hypersonic Airbreathing Weapon Concept (HAWC) program.



**2016** DARPA awards Tactical Boost Glide technology demonstration program to Lockheed Martin.

# Why is Hypersonics Capability Important?

California Institute of Technology aerodynamicist Tsien Hsue-shen coined the term hypersonics in 1946 to broadly describe flight at speeds of Mach 5 and higher. With the growing belief in some defense circles that speed could be the new stealth for the 21st century, research in this regime continues to focus mainly on key issues associated with aerodynamic heating, propulsion and flight control.

Hypersonic weapons offer advantages in four broad areas. According to a 2015 report by defense research group the Mitchell Institute for Aerospace Studies, these include the ability to project striking power at greater range while compressing the shooterto-target time window. The weapons also open new engagement opportunities, address numerous types of strikes and enhance future joint and combined operations.

Advances in thermal protection have already enabled space vehicles and missiles to survive hypersonic atmospheric reentry but continue to be at the heart of studies to develop viable boost-glide and maneuvering hypersonic vehicles. For weapons, these capabilities enable changes to flight trajectories that would significantly reduce overflight issues, reduce vulnerability to interception, boost cross-range divert capability and allow for flight profiles that can hide the intended destination.

The other main hypersonic research area is high-speed air-breathing propulsion for both boost-glide vehicles and hypersonic cruise missiles. The focus is on development of operational scramjet engines, either as stand-alone powerplants for rocket-boosted vehicles or as part of combined-cycle propulsion systems. ©

# **Ready To Roll**

# Boeing prepares to unveil 737-9, debut 737-8 as it considers 787-10X gear options

## **Guy Norris Seattle**

**NORRIS/AW&S** 

GUY

ith the rollout of the first Boeing 737-9 fast approaching and certification of the first member of the MAX family, the 737-8, expected within "days or weeks," Boeing is entering the busiest phase yet of its new-generation twin development plan.

At the same time, Boeing is also close to completing final design of the next MAX model, the 737-7, and pretion increase, which is scheduled to involve step-ups to 52 per month in 2018 and 57 in 2019, will include a progressively higher mix of MAX aircraft as assembly transitions from the current 737 Next Generation between now and the end of the decade. Given the vital importance of the 737 to Boeing's bottom line—and the fact that at least 530 of the 765 aircraft it expects to deliver in 2017 will be 737s—the company



paring for entry into service of the initial 737-8 in the second quarter. Design work continues on the high-densityseating MAX 200 version of the 737-8, while the company's Product Development organization is meanwhile planning validation tests this year of a redesigned main landing gear system as part of trade studies for the fifth, and final, MAX family member, the stretched 737-10X.

While this frenetic new product development and introduction phase is underway, Boeing is concurrently in the final stages of preparing to ramp up the monthly production rate of the 737 to 47 later this year. The producknows there is no room for error.

Final flight tests of the 737-8 are imminent, says 737 MAX Vice President and General Manager Keith Leverkuhn. "We have one test left to go where we find electricity in a cloud and build up the P-static," he says, referring to evaluation of the aircraft's resistance to electromagnetic threats caused by the buildup of precipitation static. P-static results from flying through, or close to, a thunderstorm, or from frictional (or triboelectric) charging caused by snow, rain or dust particles hitting the front of the aircraft.

While test aircraft 1A003 hunts for

suitable P-static conditions, the final operational test aircraft, 1A004, is conducting the final round of ETOPS testing. The aircraft, based at Boeing Field in Seattle, conducted a singleengine ETOPS diversion test flight on Feb. 14. "We have two flight tests left for ETOPS to validate that the aircraft and its systems are ready for long-range flight and the potential for long diversions," Leverkuhn says.

From an overall program perspective, however, the bulk of flight testing is complete. "We have turned over the information to the FAA, and we are anticipating our certification within a matter of days or weeks," he says. "We are very close. We have always been [aiming to] nail the first quarter as the date for getting amended type certifi-

cation for the airplane, and there is little doubt we will be able to accomplish what we said."

Initial customers due to accept delivery of the first 737-8s in the second quarter will "include" Norwegian Air Shuttle and MAX launch operator Southwest Airlines. "We are holding to that

#### The first Boeing 737-9 is expected to be rolled out at the end of this month and make its first flight in April.

second-quarter delivery date with good confidence," says Leverkuhn. He notes that several airlines will be among the group accepting the initial batch of 737-8s that will make up 10-15% of 737 deliveries (approximately 50-75 aircraft) this year.

Not including the first four test airframes, Boeing has already completed 13 production-

standard 737-8s. As these were built during the flight-test program, some changes are required to incorporate lessons learned from the certification campaign and the start of the assembly process. "The good news is the statement of work associated with that is pretty small, and most has to do with the things we have found during build rather than flight test," Leverkuhn says. "Lots of it has to do with wiring and how it is routed through the aircraft."

Production of the initial MAX aircraft currently continues along the dedicated "central" line set up at Renton, Washington, to enable production

of the new airframe without disrupting the flow of 737NGs along the two adjacent lines at 44 per month. The buildup of the central line accounts for the coming increase to 47 per month in the third quarter, as Boeing prepares to begin blending the MAX into one and then both of the current 737NG lines.

First flight of the 737-9 is meanwhile targeted for April, Leverkuhn notes. The flight-test program for the longer variant is expected to be shorter and less complex than that for the -8. It is planned to last just nine months and involve only two aircraft. Flight tests of the 737-8 began in January 2016 and ultimately involved four aircraft specifically for the flight-test and certification work. For the -9, "we will have one significantly instrumented aircraft [for stability and control] and one with light instrumentation that will be not too different [from] the MAX 8 No. 4 test aircraft, which was used for function and reliability work," Leverkuhn says.

Development of the shortest model, the 737-7, has now reached the 90% drawing-release stage. "Both the -9 and the -7 have gone extremely well from the [drawing]-release standpoint," says Leverkuhn. Design stability was essential to ensuring that the new models were "rate-hardened" in readiness for the production increases underway, he notes, adding that "we didn't want to stumble." The 737-7 work statement became more extensive in mid-2016 following Boeing's decision to add two seat rows as part of a revamp to boost market prospects for the slow-selling variant. The changes resulted in a 76-in.-longer fuselage and improved fuel capacity for greater range as well as better field performance.

Boeing also is continuing to evaluate a variety of main landing gear configurations for the proposed 737-10X stretch, despite having settled primarily on a trailing-link design as the basis for the model. The -10X will incorporate two fuselage plugs to increase overall length by 66 in. and will have a slightly higher maximum takeoff weight, says Leverkuhn. "Frankly, the big change here is the gear," he says. "How can we get that airplane to both take off and land standing on its 'tip-toes' while at the same time having a gear that fits in the wheel well of the MAX today?

"We anticipate we will be validating those designs through development tests this year to see which one of the trades we are looking at both for the production system and the airplane," he continues. "The trailing link is certainly part of it, but I'd say we probably haven't traded anything off the airplane yet. It is about how efficient we can be in the design, and whatever we do, it has to be very reliable because we still anticipate—despite the size of the aircraft and its transcontinental range—that it still is going to be operating on short sectors." Part of the design study is believed to include configurations incorporating both a trailing link with a compressible, telescoping gear design studied as part of earlier -10X concepts. 🗞

Gallery See the manufacturing processes and progress of the first 737-9: AviationWeek.com/First737-9



# Split Stable

# As dust settles on Virgin merger, Alaska addresses fleet strategy

#### Adrian Schofield

laska Air Group is beginning to grapple with one of the most difficult questions of any airline merger what do you do with a new fleet of aircraft that does not match your own?

This dilemma is particularly stark for Alaska Air. CEO Brad Tilden admits the carrier has been "proudly" all-Boeing in its mainline operation for several years. Now, however, it has acquired Virgin America, which has an all-Airbus fleet. And a further complication is that Virgin has many more Airbus narrowbody aircraft on order.

Although Alaska Air notes that a complete answer will not come until later this year, it has shown the first indications of how it will address its fleet issues.

The initial focus is on Virgin's order for 10 Airbus A321neos, which are scheduled to arrive over the next two years. These aircraft will be leased from GE Capital Aviation Services.

The group intends to take "some number" of the A321neos due in that period, although it does not want all of them, Chief Financial Officer Brandon Pedersen told analysts during a recent earnings call. The company is working with the lessor and Airbus to "reduce that commitment or put it off," says Tilden.

Another order on the horizon is for 30 A320neos. These are not due to be delivered until 2020, and an Alaska executive describes these orders as "cancelable," meaning there would be a relatively low termination cost.

A broader—and related—question is what Alaska Air Group will do with the 63 Airbus narrowbody aircraft Virgin currently operates, most of which are leased. The carrier must decide whether it will revert to a single-type mainline fleet in the long term or continue to operate both brands, notes Tilden. This question will be addressed over the next 6-9 months, after talks with Airbus and Boeing, he says.

In the meantime, the group will examine its expanded fleet and assess where the different types can be most efficiently deployed. Executives have signaled there could be changes in aircraft size on some routes. As a general principle, Alaska sees the A320 as better suited to "north-south" routes rather than transcontinental flying. The A321neos, however, could work on transcontinental or Hawaii routes.

The Virgin acquisition closed in December, allowing Alaska Air Group to start work on the lengthy and complex task of integrating the two carriers. More details of these plans will be revealed during Alaska Air's investor day in late March. However, the carrier said it has nearly completed work on its branding strategy, and this will likely be announced before the investor day.

Alaska Air Group is the parent of Alaska Airlines and Virgin America. It aims to have both carriers operating under a single operating certificate about a year from now, and it expects to transition to a single passenger service system in the second half of 2018.

Alaska added codeshares on all Virgin America flights soon after the acquisition closed. Already about 15% of Virgin's operating revenue is being booked through Alaska Airlines.

In terms of networks, Alaska Air is signaling that the Virgin America operation will remain largely the same. However, there will be some schedule and aircraft changes this year and more in 2018.

Looking at lessons from past U.S. airline mergers, "we realize labor deals are a big deal," says President and Chief Operating Officer Ben Minicucci. He stresses that it is "an extremely high priority for us" to get harmonized labor agreements in place by the end of 2017 or early 2018.

Wolfe Research analyst Hunter Keay describes the integration risks as "reasonable." He notes that Alaska Airlines and Virgin both use the Sabre passenger service system and will "lean on [Air Line Pilots Association] protocols for

DEPRIESAVIATION.NET



Alaska Air Group will decide this year whether it will retain Virgin America's A320s in the long term.

sensitive labor issues such as seniority list integration and, if needed, pay scale arbitration."

Alaska Air Group's sound financial position also helps. The carrier reported a net profit of \$814 million for 2016, and the profit excluding special items was a record \$911 million—representing its 13th consecutive year in the black. The airline achieved an impressive pretax profit margin of 24%.

The Virgin merger seems unlikely to stall this momentum. The acquisition was "accretive [to earnings] out of the gate" in late 2016, and this is also expected to be the case in 2017, Tilden says. The carrier's strong results and balance sheet allowed it to finance the Virgin purchase without issuing new equity.

Aside from the A321neo question, Alaska Airlines has more fleet modernization planned. It is due to receive 12 Boeing 737-900ERs this year, which will replace 10 737-400s that are being retired. Three 737-700s are being modified into freighters to replace five 737 combis and one -400 freighter. On the regional side, the carrier plans to add 18 more Embraer 175s to its network, operated by SkyWest Airlines.

The group had 218 mainline aircraft as of Dec. 31, including 149 737s, six 737 freighters or combis, and the 63 Airbus A320-family aircraft operated by Virgin America. The planned fleet changes will leave the total about the same by the end of this year.



# 





# **Getting Creative**

# Legacy and low-cost carriers are copying moves from each other's playbooks

#### **Helen Massy-Beresford Paris**

The European airline industry is proving the old adage that necessity is the mother of invention. Faced with fierce competition and falling fares, terrorism fears that have leisure travelers postponing trips, and concerns over fuel prices, legacy carriers and their low-cost rivals are getting creative to survive, blurring the boundary between their traditional roles.

But will their new strategies work? And will they go far enough?

Legacy carriers including Air France, Lufthansa and International Airlines Group (IAG) are exploring a part of Lufthansa, through its Eurowings operations, Air France with its "Boost" project and IAG through its plans in Barcelona, Spain, recognize that longhaul low-cost is emerging as a force to be reckoned with.

Competing with the likes of Norwegian—which flew about 30 million passengers in 2016—will be a big challenge for these carriers, however.

As John Strickland, director of JLS Consulting, points out, there will not be one right answer as to how to go about it. "Long-haul, low-cost is not nearly as established as short-haul, low-cost has



Air France will use Airbus A320s for the medium-haul operations of its new airline, currently dubbed "Boost."

the business they have traditionally left alone—low-cost, long-haul services.

Meanwhile, Scandinavian Airlines' plan to obtain an Irish air operator's certificate and set up lower-cost bases in London and Spain is an example of another tactic in the battle for greater competitiveness, as the Scandinaviafocused carrier looks beyond its highcost home markets for cheaper bases that could help it grab a bigger slice of the growing demand for leisure travel.

And low-cost carriers (LCC) are adapting to the new industry reality by increasingly positioning themselves as feeder services for legacy carriers.

Legacy airlines that were caught offguard by the arrival of short-haul LCCs 20 years ago are keen not to make the same mistake again, now that they face the threat of low-cost, long-haul flights. become, and it is not clear how broadly and sustainably profitable it can be made." The big European legacy airline groups may all have pinpointed the same trend, but as very different groups they will need different strategies to compete with it.

Air France's "Boost" project is part of broader turnaround plans the Air France-KLM group unveiled last year. The French carrier aims to increase its competitiveness against its rivals, including those from the Gulf, by setting up a new airline that will provide a passenger experience comparable to Air France flights but with lower organizational costs that keep prices down.

"We came to the conclusion that we had to find ways to have a more competitive offer and that it was very difficult to create this competitiveness within Air France," he told a press conference in Paris on Feb. 9.

And with a target of 15-18 Airbus A320s for medium-haul routes and 10 long-haul aircraft by 2020—Airbus A350s are being considered—will the setup be enough to make a difference?

"Air France's Boost proposal doesn't look very clear at the moment—we're talking about fairly limited cost reductions," says Strickland.

Lufthansa, for its part, is taking a careful approach, positioning the fledgling long-haul services it has launched through its predominantly short-haul Eurowings brand on leisure routes, allowing it to stimulate demand with cheaper fares from Cologne, Germany, without encroaching on high-margin business travel through its Frankfurt and Munich hubs.

Strickland is more upbeat about IAG's plans to launch low-cost, longhaul operations from a base in Barcelona, and on its moves to compete directly with Norwegian at London's Gatwick Airport with higher capacity Boeing 777s, partly because the group overall is better placed financially than Air France-KLM.

IAG, parent company of Aer Lingus, British Airways, Iberia and Vueling, said in December it would offer lowcost Barcelona-U.S. services this June.

CEO Willie Walsh said on Feb. 8 that the low-cost, long-haul operations would become a significant part of the group and that Barcelona was just the beginning. IAG has not yet said whether the long-haul operations will come under an existing group brand or a new one. Walsh confirmed Airbus A330s would be used.

And IAG is also spared the labor challenges faced by Air France and Lufthansa.

Meanwhile, the LCCs responsible for shaking up the European airline industry's status quo a generation ago are also having to adapt to a changing context. Ryanair CEO Michael O'Leary predicts that feeder arrangements between low-cost carriers and legacy airlines would become commonplace in Europe in five years because of the lower costs involved.

Convincing skeptical legacy carriers to cooperate may be a challenge for LCCs. Ryanair has reached an agreement with Norwegian, but information-technology integration issues are delaying the launch. O'Leary plans to work with other carriers "in the summer."



# Join Us for UNRIVALED, POWERFUL FACE-TO-FACE COLLABORATION

# **We Deliver!** Global Space Leaders and Visionaries Powerful Agenda



Elżbieta Bieńkowska Commissioner European Commission



Winston A. Beauchamp Deputy Under Secretary of the Air Force for Space; Director Principal DoD Space Advisor Staff U.S. Air Force



Leanne Caret President and Chief Executive Officer of Defense, Space & Security (BDS); Executive Vice President The Boeing Company



**Dr. Naoki Okumura** President Japan Aerospace Exploration Agency (JAXA)



Gen. David L. Goldfein, USAF Chief of Staff U.S. Air Force



Gen. John E. Hyten, USAF Commander USSTRATCOM



Gen. John W. "Jay" Raymond, USAF Commander Air Force Space Command

# Featuring

## Expansive Boeing Exhibit Center and Pavilion – Sold Out

Meet with exhibitors from all over the world

Profitable Connections – Don't miss our many informative, memorable events to connect with your industry and customers

# Popular Networking Events Include:

- Yuri's Night
- The Space Warfighters Luncheon
- General James E. Hill Award Luncheon
- Space Technology Hall of Fame<sup>®</sup> Dinner
- New! Women's Global Gathering Luncheon

# We Deliver 33 Years of Excellence!

There's Still Time to Savel On Industry Registration Discount Ends Soon! Reduced Pricing! Active Duty Military and Government

www.SpaceSymposium.net +1.800.691.4000 Official Media Partner

AVIATION WEEK

# Souped-Up Super Hornet

Boeing is reviving the conversation about an upgraded F-18 fighter for the U.S. aircraft carrier air wing

#### Lara Seligman Washington

s President Donald Trump signals he may reconsider the mix of F-35Cs and F/A-18s for the carrier air wing of the 2020s and beyond, Boeing is pitching an upgraded "Block 3" Super Hornet designed to add firepower and act as a smart node on the U.S. Navy's future network.

While the service's first F-35Cs will come online in 2018, the F/A-18 E/F Super Hornet will make up at least half of the carrier air wing through the 2040s. The challenge is to keep the Super Hornet, an airframe originally designed in the 1990s, relevant and effective against advanced threats into the middle of the century.

That issue is nothing new for Boeing, but the discussion about the next step for the Super Hornet has shifted in the past few years. While the "Advanced Super Hornet" Boeing proposed in 2013 focused on stealth, the new and improved Block 3 is designed to optimize the Navy's integrated network architecture, says Dan Gillian, Boeing F/A-18 and EA-18 program manager.

The big question for the carrier air wing through the 2030s, says Gillian, is: "How can the Super Hornet evolve in a complementary way with the E-2D [Hawkeye] and Growler to help address some of those carrier gaps?"

Boeing believes the Navy could detail a plan to procure the Super Hornet Block 3 as soon as the fiscal 2018 budget proposal, expected this spring. A fiscal 2019 buy would mean Boeing could have aircraft off the production line in the early 2020s, Gillian notes.

The revived conversation about the advanced Super Hornet is emerging just weeks after Trump made headlines by pitting the naval strike fighter against Lockheed Martin's F-35. In a blow to Lockheed, he asked Boeing to price out the cost of building a "comparable" Super Hornet as a possible alternative to the F-35C carrier variant, and Secretary of Defense James Mattis has since ordered a review comparing the two aircraft.

However, Gillian would not say definitively whether Block 3 could replace the F-35C in the carrier air wing. Boeing is focused on "complementary capability," and ultimately the Navy will decide the right mix of each platform, he stresses.

"We are supporting Block 3 as a key piece of solving the carrier air wing capability problem," he says. "Our job is to present solutions to solve their warfighting problems."

Gillian envisions a Block 3 Super Hornet working in tandem with the stealthy F-35C, the Growler's fullspectrum jammer and the E-2D's early-warning capability to dominate the skies. The addition of a long-range infrared sensor (IRST) will allow Block 3 to detect and track advanced threats from a distance, while conformal fuel tanks (CFT) will extend range by 100-120 nm. The CFTs are designed to replace the extra fuel tanks Super Hornets currently sling under the wing, reducing weight and drag and enabling additional payload.

These changes could enable a fully loaded Block 3 Super Hornet to operate in conjunction with a stealthy F-35, providing air cover and greater magazine depth.

"You can have an F-35 in its very stealthy way doing a deep-strike mission, with Super Hornet providing air superiority at that same range, or you can have Super Hornet carrying large standoff weapons that F-35 cannot carry, with F-35 providing some air cover," Gillian says. "You get very mission-flexible, so range is important."

Certain features of the 2013 proposal, such as the enclosed weapons pod and internal IRST sensor, were dropped from the 2016-17 package because Boeing's analysis determined the Super Hornet was "stealthy enough"—it can fly full-up and still be survivable. Boeing engineers found they needed to make design compromises to significantly reduce the aircraft's radar cross-section for instance, by restricting payload.

"At some point, we drew a line that would allow us to be stealthy enough in a balanced survivable way to be effective, and that is what we think we have," Gillian says. "The F-35 is a stealthier airplane, but we have a balanced approach to survivability including electronic warfare and selfprotection."

Block 3 also features an advanced

computing infrastructure designed to take advantage of the future carrier air wing's sophisticated sensor architecture. The aircraft will have an advanced cockpit system with a large-area display for improved user interface, a more powerful computer

#### Boeing is pitching an upgraded Super Hornet "Block 3" for the U.S. Navy.

called the Distributed Targeting Processor Network (DTPN) and a bigger data pipe for passing information known as Tactical Targeting Network Technology (TTNT). TTNT is already a program of record for Growler and E-2D, and DTPN is also fielded on the Growler.

"You have your IRST sensor, you have other sensors in the carrier air wing, you need a big pipe to move that information around, then you need a big computer to be able to fuse all that information together," Gillian says. "Block 3 Super Hornet needs to be a smart node on the network capable of crunching and passing data across the network to other assets."

This advanced computing architecture would ensure the Super Hornet, Growler and E-2D could talk to each other and pass critical threat data over the same network in combat. However, the F-35 is not on TTNT; rather it uses the smaller-bandwidth Link 16 network to pass and receive data from fourth-generation aircraft.

The result is that while the F-35C can communicate with the rest of the carrier air wing, passing large amounts of data may be difficult.

While improving fifth-to-fourthgeneration connectivity is an ongoing discussion, "I think the question is: how does F-35 plug in with everybody else?" Gillian says. "If everybody else is on TTNT, there seems like an obvious answer there."

The Navy could probably add TTNT to the F-35's Link 16 functionality, but the fighter cannot broadcast on any Link 16 waveform without compromising its stealth, because Link 16 is not a low-probability-of-intercept waveform. The F-35 can pass large amounts of data to other F-35s via the stealthy Multifunction Advanced Data Link, which most other aircraft cannot currently access.

Another difference between the 2016 and 2013 proposals is that Boeing is offering to deliver a 9,000-hr. airplane straight off the production line, Gillian says. Combined with the company's ongoing effort to extend the existing Super Hornets to 9,000 hr. from 6,500, this will help the Navy maintain inventory and boost readiness, he says.

Although the Navy has not publicly committed to Block 3, Gillian thinks the service is very interested in the capability.

"I believe there is a general acceptance of the fact that we need to advance the Super Hornet, because it is going to be a front-line fighter [from the] 2020s into the '40s," Gillian says. "We believe we have good alignment on the Block 3 Super Hornet systems that address key carrier air wing gaps in a complementary way with the F-35, E-2D and Growler." 🐼



View the preliminary program at aeromontreal.ca



Québec's Aerospace Cluster

# Grounded

# Across the U.S. services, just a fraction of strike fighters can fly

#### Lara Seligman Washington

he U.S. military relies on its strike aircraft for missions across the world, from fighting terrorists in the Middle East to deterring Russian aggression in Europe. But today those fighters are exhausted from decades of combat, and the military does not have enough money to keep up with critical maintenance work.

The result is a hollow fighter force across the armed services. On a given day, fewer than half of U.S. Marine Corps F/A-18s, just over half of U.S. Navy F/A-18s and fewer than threequarters of U.S. Air Force fighters can fly, the rest grounded while they await maintenance or spare parts (see tables).

The low number of what the Pentagon calls "mission-capable" fighters across the service is troubling, but it is not the whole picture. The readiness numbers the services report do not reflect the total inventory of fighters the military owns, because they do not include the additional aircraft in long-term depot maintenance. When accounting for these aircraft, the percentage of fighters that can fly on a given day drops dramatically—to onequarter of all Marine Corps F/A-18s and just over one-third of the Navy's total Hornets and Super Hornets.

The Air Force declined to provide information about total aircraft inventory.

Such remarkably low numbers paint a dismal picture of military readiness at a time when adversaries are developing ever-more-sophisticated surface-to-air missiles and other antiaircraft weapons. The vice chiefs of staff of each of the services pleaded their case before the House and Senate Armed Services Committees Feb. 7-8, urging lawmakers to stop the bleeding. If the government does not stem the massive maintenance backlog, the U.S. fighter force will not be able to surge in the event of a crisis, they say.

"The capacity in our depots has been diminished since sequestration and furloughs back in 2013, and we're trying to rebuild that capacity today to try to get those jets turned around," says Adm. Bill Moran, vice chief of naval operations. "We can and we do put ready airplanes and ready crews forward on deployment. There's no depth on the bench to go behind them, though, if we had to surge forces."

The military has struggled for years to maintain combat-ready aircraft, a challenge driven by deep sequestration cuts and poor budget planning. But this year, the Pentagon is likely looking to capitalize on the very real possibility that President Donald Trump's administration will succeed in if not lifting the budget caps altogether, at least boosting defense spending by tens of billions of dollars.

The Marine Corps' F/A-18 Hornets are facing an especially critical shortfall. Out of the 171 "in-reporting" F/A-18s—the aircraft on the flight line assigned to squadrons—just 72, or 42%, were flyable on average for the month of December, according to Lt. Gen. Jon Davis, the service's top aviator.

But these numbers do not include an additional 109 aircraft in depot maintenance. The Marine Corps does not count these aircraft when it reports its mission-capable rates because depot-level maintenance is, for the most part, deliberately planned and scheduled, says service spokeswoman Capt. Sarah Burns.

Nonetheless, accounting for the additional aircraft, the number of Marine Corps F/A-18s that are grounded due to maintenance is a staggering 74%.

Davis says the Marine Corps is working its way out of the readiness "bathtub" caused by sequestration cuts. Since December 2014, the service has added 43 flyable aircraft, he notes. But Marine aviators are still far short of their flight-hour goals. In fact, the last time the Marines met this target was in 2012.

"I'll tell you the moral of the story: In the aggregate, if I'm a businessman, I'm underwater right now, because I don't have enough power tools to make my flight-hour goal," Davis says.

Meanwhile, just 52% of all in-reporting Navy F/A-18s cannot fly, including 44% of legacy Hornets and 54% of Super Hornets, according to Navy spokeswoman Cmdr. Jeanette Groeneveld. Again, this does not reflect the total inventory of 795 Navy F/A-18s. When accounting for the 188 aircraft in long-term depot maintenance, 61% are down, including 76% of legacy Hornets

## U.S. Military Aircraft Readiness

Flyable Aircraft Out of Aircraft Available to Units*		
<b>Marine Corps</b> F/A-18s (A-D)	42%	
<b>Navy</b> F/A-18s (A-D and E/F)	52%	
<b>Air Force Strike Fighters</b> (A-10, F-15C-E, F-16C-D, F-22A, F-35A)	71%	
Flyable Aircraft Out of Total Inventory**		
<b>Marine Corps</b> F/A-18s (A-D)	26%	
<b>Navy</b> F/A-18s (A-D and E/F)	39%	
Air Force	NA	
*"Mission capable" or "in-reporting,"		

does not include those in depot

\*\*Including those in depot

Sources: U.S. Marine Corps, U.S. Navy, U.S. Air Force

and 53% of Super Hornets.

These readiness levels reflect just how hard the Navy has flown those aircraft over the last 15 years, Moran told lawmakers Feb. 8.

The problem for the Navy F/A-18s begins in the depot. There, maintenance of legacy Hornets is backed up as maintainers wait for specialized spare parts to arrive, says Dan Gillian, Boeing's vice president for the F/A-18 and EA-18. The backlog of legacy Hornets in the depots has a domino effect on the rest of the fleet, as Super Hornets are forced to wait longer than planned for depot spots. That also trickles down to the F/A-18s in squadron, as some of the jets are sidelined waiting for the same spare parts, Gillian says.

In the air arm, the situation seems more manageable. The F-22A Raptors and F-15Es are in the worst shape, with just 60% of in-reporting aircraft able to fly. The venerable A-10 Warthog is the most ready, with 76% mission-capable. Across the fighter



force, 71% are available on a given day. However, this does not account for the aircraft in depot maintenance.

This shortfall means pilots get less of the crucial flying time they need, Gen. Stephen Wilson, Air Force vice chief of staff, told lawmakers Feb. 7. Today, Air Force pilots are averaging 14 flight hours and 10 sorties a month fewer than they were during the "hollow-force" years of the late 1970s, and far too few for the missions they need U.S. NAVY

to be able to fly. Wilson estimates it will take 6-8 years to bring readiness levels back where they should be.

Building up flying hours is critical to preparing for a high-end fight against a near-peer competitor like Russia or China, Wilson says.

In the meantime, there will be serious consequences at home if there is no defense budget relief this year, the vice chiefs told lawmakers Feb. 7. If funding is flat for the remainder of

U.S. Air Force Combat Aircraft Readiness	
	Mission Capable Rate
A-10C	74%
F-15C	71%
F-15D	60%
F-15E	73%
F-16C	73%
F-16D	69%
F-22A	60%
F-35A	65%
Average	71%

Source: U.S. Air Force

the fiscal year, the Marines and airmen at home stations will stop flying this summer.

"For us, the shining example is we would stop flying at about July," Gen. Glenn Walters, assistant commandant of the Marine Corps, told lawmakers Feb. 7. "The guys that are [forwarddeployed] will still fly. But all those flying in the continental United States all training would cease without the supplemental [funding]." 

# Strategic Planning Simplified



# Data and Insight to Maximize Revenue

#### Aviation Week Network's 2017 Military Fleet & MRO

**Forecast** is the unsurpassed resource for providing insight into the future of the military aviation market, allowing users to compose plans, devise strategies, assess markets and maximize revenue generation. The forecast covers all Western-designed, piloted military aircraft—over 40,00 aircraft of over 1,200 types—with projections for every type and operator for each of the next ten years.

#### Gain a competitive advantage. The easy to use interface simplifies:

- Discovering future in-service fleets by aircraft family or variant; manufacturer, mission & submission category, aircraft weight class, any combination of these and more
- Obtaining details on deliveries and retirements, broken down by type and certainty
- Understanding MRO requirements projections for these fleets, including utilization; field maintenance, labor & materials; and depot maintenance for airframes, engines and 12 categories of components

# See for yourself. Contact us today:



Aviationweek.com/2017forecast | 1.866.857.0148 or +1.847.763.9147



# Beyond Blackwater

Erik Prince, a 47-year-old former U.S. Navy SEAL, is best known as the founder of Blackwater, the erstwhile private security company that garnered some notoriety during the Iraq war. He is now executive director and chairman of Frontier Services Group (FSG), a publicly traded company based in Hong Kong. Founded by Prince and entrepreneur Johnson Ko, FSG offers air, sea and ground transportation services for customers in underdeveloped or hostile areas faced with complex security and logistical challenges, such as oil and gas operators in Africa. FSG's fleet of more than 20 mostly used aircraft includes four Citation Bravos, two King Air BE-200s, two Boeing 737-300s, an Antonov AN-26 and other fixed-wing airplanes, as well as a Bell 412 helicopter. Prince—whose sister, Betsy DeVos, became U.S. Education secretary on Feb. 7—recently sat down with Aviation Week editors in Washington.

# *AW&ST:* What is Frontier Services Group (FSG)?

**Prince:** Our mission is logistics in developing areas. We do everything from transportation, trucking and warehousing to delivering groceries from Cape Town, South Africa, all the way up through Congo. On the aviation side, we have Phoenix Aviation in Nairobi. We're the largest medevac provider for United Nations (U.N.) peacekeeping operations. We also provide high-speed liaison and transport for U.N. and peacekeeping officials. Then there is Maleth Aviation, based in Malta, which does aviation fleet management and charters.

# You seem to be significantly expanding your aviation operations.

[We're expanding our focus on Asia] to link East Asia with the rest of the world in trade, both in maritime and aviation. We'll be kicking off some initiatives for aviation in Somalia and South Sudan and some other really underserved markets where it is hard to fly around safely. Whether it's an early-stage nongovernmental organization trying to stabilize a country or early-stage investors, you need survey crews, engineers and core drilling people to invest into a society to build an economy. Moving those people safely in and out is key, and people do pay for it. When the Asian investors came and said, 'We want you to build a logistics business in Africa,' I said, 'You have to start with aviation,' because it's hard to do and it gives you far-market access in most weather that vehicles just do not. Much of Africa and [similar] places still move to the rhythms of the rainy and dry seasons. Some months, you're just not going to drive anywhere, and so you have to fly. One of the first big contracts for FSG was to support the South Sudan petroleum industry, because they had some conflict flare up and needed to be linked to an essenFRONTIER SERVICES GROUP

tial oil field in the north. If you can't get parts or lubricants to your people, the entire place would shut down. The roads were muddy or blocked by some rebel activity—the Nile River was not navigable because of the rebels—so an air bridge was the only way to provide a link.

# You describe FSG as full-service airlift. What does that entail?

In the Presidential Airways days, the previous [Blackwater] aviation company, we had 73 aircraft. Most never came back after they deployed. So we would send the mechanics, parts, backup engines and everything with them—a military supply ship doing remote medevac and resupply for the U.S., which was training local forces in the area. In Afghanistan, we had 22 aircraft on the ramp in Bagram Air Base, and they were doing engine changes in the middle of an Afghan winter with no hangar. This is different. It's being able to operate out of the comfort of a hangar with the regularity that a domestic operator has.

# **EXERTIES**

Tomorrow's Engineering Leaders

# **Congratulations to the Next Generation of Aerospace Leaders**

**Aviation Week Network, in association with AIAA,** congratulates this year's 20 Twenties honorees for their outstanding academic accomplishments.

- > Keenan E. S. Albee, Columbia University
- Geoffrey Andrews, Purdue University
- > Jakob Bludau, Technical University of Munich
- Julia CrowleyFarenga, Purdue University
- > John L. Deaton, U.S. Air Force Academy
- > Julia Di, Columbia University
- > Jennifer Domanowski, Boise State University
- **Karl Domjahn,** The University of Queensland
- Alexander W. Feldstein, Massachusetts Institute of Technology
- > Brian Free, University of Maryland

- ► Kelly Henckel, University of Michigan
- > Rebecca E. Hill, University of Michigan
- > Matthew Ryan Hurst, University of Colorado, Boulder
- Rubbel Kumar, University of Maryland
- > Braven C. Leung, Georgia Institute of Technology
- > Wanyi Ng, University of Maryland
- > Kristen Railey, Massachusetts Institute of Technology
- > Christine Reilly, University of Colorado, Boulder
- > Rose Weinstein, University of Maryland
- > Emily Marie Zimovan, Purdue University

# To learn more, go to:

# Aviationweek.com/FutureLeaders





## Are you providing security for these operations, as well?

No. It is assumed that some local or U.N. peacekeeping force has already secured the airfield. FSG offers civilian aviation in difficult and dangerous places. We're not doing military tactical aviation like the Blackwater guys used to do. Nobody is armed on our aircraft. It may be security work in the sense of helping a customer [most expediently place] lights and fences. But the security would always be done by some local partner. It's a totally different approach [from Blackwater].

#### FSG's in-country focus is also different, no?

When Chinese companies go into Africa, they tend to bring everything with them, down to the cook and the guy that cuts hair. It becomes a Chinese bubble. Western companies, having operated in those places longer, have a more adaptive approach; they hire more locals and buy more food locally, and that helps community relations. The number of highways, infrastructure and power plants that the Chinese have built has had a significantly positive effect in many parts of Africa, but helping them adapt to be more user-friendly to the local communities is essential. FSG, in a security sense, might help them manage a local security capacity better, but the answer is not 100 armed Americans. It's not 100 armed Chinese, either. It's whatever the right number of security people is, from the local community, professionally managed and organized.

#### Where are you focusing now?

We're focused on Africa, and see significant growth opportunities in South Asia and Western China. China has a huge overcapacity issue-they can manufacture a lot, but unless they have logistics channels for export and trade, they're limited. They need to import a lot of energy and export a lot of goods. There are some big initiatives we have underway-key projects that link our ability to operate on air, ground and water, and to make difficult missions possible in Central and West Africa. Whether it's in Pakistan, Kazakhstan, coming out of the northwest province in China, touching against Afghanistan, there is still

significant mining, rail, infrastructure activity, all of which needs quality aviation support. We will be that provider.

#### Will you grow your aircraft fleet?

We are certainly open to buying more, ranging from midsize jets and probably even heavier cargo, to be able to carry at least 463L master pallets, big ones, on the Boeing 737 or higher. Personally speaking, I have a bias toward buying used aircraft. If you have good maintenance, you can operate a fleet with very high operational readiness at significantly lower cost. That was my experience with the Presidential Airways fleet. Everything, with the exception of the Super Tucano and a Cessna Caravan, was used because of the unique nature of the kind of aircraft we had to have: a ramp aircraft that you could put under U.S. certificate. There were not a lot of those out there that were affordable and new. I'm not going to spend \$15 million for a new CASA 212 that I could buy for \$800,000 used.

## There is a big inventory of used airplanes for sale.

There is. We bought a new Citation Sovereign, and that's working fine, but the rest has mostly been used aircraft that are well-maintained and efficiently operated. Oil and gas guys demand new aircraft, but with \$40-50-perbarrel prices, that [demand] has significantly pulled back.

#### **Does FSG have competitors?**

There are some South African air operators, but they're not aspiring to be a pan-African operation, and they don't provide integrated ground-airmaritime logistics. [FSG also offers] business interruption insurance. I wouldn't feel comfortable saying we'll stand behind a project's insurance unless we had a truly integrated support package.

#### U.S. President Donald Trump has been critical of China. Do you see any of his statements or tweets interrupting your business?

[Trump's comments] have to do with bilateral trade and tariffs between the U.S. and China. Whether it's Chinese-, French-, British- or U.S.-funded, mining activity in Africa will keep us busy. Commodity prices have started to rebound, and our business will be lifted by a growing economy. If lowering taxes and reducing regulation helps take the U.S. economy from 2% growth where it's bumping along now—to 4 or 4.5%, that would provide a fantastic lift to commodity prices globally. It would be very good for our business, because there is going to be more mining and drilling, infrastructure, farming and job growth all across Africa and Asia.

#### You have criticized elements of the U.S. approach in Iraq and Afghanistan, including airpower. What was wrong?

Everyone says irregular war and counterinsurgency efforts are the exception. The data prove that it is quite the inverse. The U.S. military keeps trying to mow the lawn with a Porsche—it's way too expensive. Until a couple of years ago, they were still flying jets off an aircraft carrier in the north Indian Ocean and [refueling in the air] to get over Afghanistan to stay on station for half an hour for a combat air support mission. That is asinine. Be expeditionary, be remote, and do composite squadrons to support it. [Otherwise,] the amount of damage on the [high-end] aircraft, the wear and tear, the fuel burn, is crazy. The average cost of a [high-end U.S. fighter] sortie over Iraq or Syria right now is \$600,000 per mission. That's just not sustainable.

#### Do you think things could change under the new U.S. Defense secretary, Marine Gen. (ret.) James Mattis?

I understand he is a real student of military history, so he knows how many bush wars there are versus the big one. The reason the Marines fought so hard to keep their own air wing was so that aircraft could support people on the ground. I would imagine he [believes] that having proper aircraft that can hang out and support people on the ground is necessary, and so much cheaper-for example, counterinsurgency aircraft that can get up and hang on station for 6 hr. without requiring a tanker and be there when troops need it. As a country, we desperately need a modern A-1 Skyraider or something similar.

# **Drone Union**

# Europe's lawmakers try to speed up passage of unified UAV regulations

#### Nicholas Fiorenza Brussels

he European Union (EU) plans to harmonize the rules for the operation of civil unmanned air vehicles (UAV) in its member states this year for implementation by 2019, European officials say.

The European Commission, the EU Council and the European Parliament will begin discussions in mid-February aimed at agreeing on the text of the regulation so it can be approved by the summer, according to Dutch member of the European Parliament (MEP) Matthijs van Miltenburg.

The regulation will extend the EU's purview to include the regulation of drones weighing less than 150 kg (330 lb.), which are currently under the jurisdiction of member states. This will give the EU oversight of all civilian UAVs in the union; it already oversees drones weighing more than 150 kg. Military unmanned aerial systems are not included.

Violeta Bulc, European Commissioner for Mobility and Transport, laid out the future of drones in the EU at a high-level conference held last November. This Warsaw declaration envisions common standards to create what she calls a U-Space, with the "U" standing for "urban" or "you," i.e., European citizens. U-Space will allow individuals and businesses to operate automated drones at altitudes below 150 m (500 ft.), including over cities. The EC has set aside €40 million (\$42.9 million) for demonstration projects to begin as soon as possible.

Bulc's deputy, Matthew Baldwin, describes drones as a disruptive, fast-moving technology requiring full automation, from air traffic management to flight. He notes a mix of public enthusiasm and fear of the technology, requiring gaining public

trust regarding safety and data privacy. UK MEP Jacqueline Foster, who led work on the European Parliament report, "The Safe Use of Remotely Piloted Aircraft Systems," says: "Nobody wants a drone flying in their back garden," adding that she does not believe remotely piloted airliners would be acceptable to the public.

Baldwin calls for quicker legislation to keep up with developments in Asia and the U.S., which is "doable," but will take "a lot of work." Foster says work on the EU regulation "needs to be speeded up," noting that her report was completed in November 2015. An EU regulation does not have to go to national parliaments for approval, unlike directives, which can take years to be ratified by the 28 member states' legislatures.

The European Aviation Safety Agency (EASA) is already working on concrete rules for all UAV operations in the EU in anticipation of the regulation being approved. In December 2015, EASA proposed a draft identifying risk profiles.

The draft foresees the safety of "buy and fly" small UAVs with low risk to third parties on the ground and to other airspace users facing minimum operational limitations, while operators of unmanned aircraft beyond visual line of sight will follow risk-mitigation measures listed in a manual. Higher risks equivalent to those of manned aviation will be covered by a traditional approach of certification and licensing.

The EU is working with industry on the regulation. One of the companies is Intel, whose associate general counsel and global privacy officer, David Hoffman, says the company sees opportunities in improving analytical algorithms, privacy and flying multiple devices. He says Intel was "encouraging beyond-line-of-sight operations while respecting privacy."

Philippe Duvivier, a business developer at Parrot Professional Civil UAVs, which sells drones and accessories online, calls for the regulation "not to be too tough" and to be future-proof "because we don't know where drones are going." Miltenburg says the regulation has to be flexible, and Joshua Salsby, a member of Bulc's cabinet, says it should not only be simple and future-proof but also "a leap forward."

At the Warsaw conference, Bulc said the technology would generate additional growth in the European economy, open-



LUFTHANSA

ing "the door to new markets for innovative services with immense potential." She wants the EU to "remain on top of this, to steer and lead the global development of this technology."

EASA's statistics show there are 2,495 operators and 114 manufacturers of remotely piloted aircraft systems weighing up to 150 kg in its 32 member states, compared to 2,000 in Japan and 342 in the rest of the world. Michal Mazur, head of drone-powered solutions at consultancy PwC, estimates the market for commercial drone applications at more than \$127 million, including \$45.2 million in infrastructure and \$32.4 million in agriculture.

Among the 50 companies competing for the first EU drone awards are manufacturers of UAVs that enter mine shafts, inspect infrastructure and locate and move objects inside factories. The winner in the best drone-based solution category, Clear Flight Solutions of the Netherlands, produces a hand-painted "robird," which looks like a hawk, to scare away birds from farmland, airports or other places.

The UAV will be deployed to a European airport this year. The drone currently flies within line of sight of its operator, but will be upgraded to fly autonomously beyond line of sight when European regulations permit this.

# **About-face**

## With used jet aircraft gaining favor, ATR is rethinking its options

#### **Thierry Dubois Stockholm**

TR 42/72 turboprop sales suffered last year from a combination of adverse market forces that put the airframer in a position its executives might have assumed was a thing of the past—competing against jets.

During the "jetmania" market shift of the 1990s and early 2000s, a new generation of 40-to-70-seat jets appealed to regional carriers. The aircraft were promoted as a way for the regionals to shed their image of being slow and outdated. Turboprop sales predictably plummeted. But when the operating cost of jets spiraled upward with the increase in oil prices, turboprops became attractive again. Their lower fuel consumption and passenger cabin improvements were touted in an environment that saw some prominent turbofan competitors fold.



But now ATR is experiencing a bit of deja vu. "In most sales campaigns [we are involved in], the customer is considering buying either a cheap used jet or a new efficient turboprop," says CEO Christian Scherer. For instance, Embraer has been placing used E170s—initially flown by U.S. carriers—into emerging markets.

The market is soft overall; ATR took orders for a disappointing 36 aircraft (34 ATR 72-600s and two ATR 42-600s) in 2016, related in part to the strength of the U.S. dollar. Citing Indonesian carriers as an example, Scherer notes that many of ATR's customers pay in other currencies, which often makes buying a used jet more affordable.

Compounding the problem is the relatively low cost of fuel, which can obviate the business case for turboprops. So jetmania has reemerged. "Everybody wants a jet; they buy one, burn their fingers [due to higher operating costs] and *then* buy a turboprop," says Scherer.

Another mitigating factor against turboprops is that many pilots view them as stepping-stones for larger aircraft, which can leave ATR customers facing a hiring problem. "Maybe we should have anticipated the pilot bottleneck," Scherer says. Also, airlines must cope with scarce slots at training organizations and simulators. In January, ATR installed an additional ATR 72-600 simulator in Paris to help alleviate that situation.

Finally, according to Scherer, there "may be a bit of oversupply in the turboprop leasing sector." Selling to lessors involves finding a middle ground to avoid competing with each other. Scherer says lessors are best placed to offer availability within 6-18 months' notice; the airframer is positioned for 18-month-distant slots.

As a result of weakening sales, Scherer has decided to "stabilize" production at 80 per year instead of the earlier announced ramp-up to 100 or more. The backlog is still reassuring, estimated at three years of production.

The supply chain, once a source of delays, is now "doing rather well," Scherer says. Leonardo and Airbus (parent companies of ATR and of its main suppliers) have agreed on a procedural change. Subassemblies are now handed over at their own factories, which means ATR is not accepting them if incomplete.

This year ATR hopes to conclude the sale of 40 aircraft to Iran Air, announced in early 2016. The outstanding issue, after a lengthy negotiation and approval process, is engine support, Scherer says. Pratt & Whitney Canada's parent company UTC must obtain a license from U.S. authorities. Farther East, efforts to sell ATR aircraft in China contin-

ue. Scherer cites two obstacles—the government's promotion and protection of Avic turboprops, and the bureaucratic difficulties faced by startups trying to gain air-operator certificates to remote

#### Due to weakening sales, ATR has stopped its ramp-up and stabilized production at 80 aircraft per year.

provinces. "But the Great Wall is not insurmountable," he avers.

Current market trends have not changed ATR's be-

lief in its aircraft's intrinsic advantages. When Sweden-based carrier BRA organized a bio-fuelthemed public relations event for using one of its brand-new ATRs, Scherer seized the opportunity to promote its products as more environmentally friendly than a jet's. The carrier and manufacturer

touted the ATR 72-600 as 50% less fuel-thirsty than an Avro RJ85/100, which BRA also operates.

Moreover, turboprops can use shorter runways. ATR is thus testing the market with a short-takeoff-and-landing (STOL) version of the ATR 42-600 that could access small airfields in mountains, fjords and islands.

The new variant would expand the 50-seat aircraft's role as a pathfinder used to open new routes, including to remote locations with 2,600-ft. runways. In Indonesia, the STOL ATR 42 would be able to link about 150 communities to larger cities and "one or two deals" are being sought.

The development of the STOL ATR 42 involves design changes, mainly for the rudder, which would benefit from a hydraulic control system in lieu of the current mechanical chain. More rudder control is needed for evasive action with one engine inoperative in a tricky terrain environment.

Carbon brakes would replace conventional steel brakes because they have better tolerance at the extremes of the operating envelope and are more durable. They are not yet on the ATR 42-600 because the cost is formidable.

A new STOL version would be consistent with the pathfinder role of regional aviation, Scherer says, citing the estimated 100 routes ATR aircraft help open every year.

# **True to Form**

# Air China can expect more competition in its home market

#### **Bradley Perrett Beijing**

hina Eastern Airlines has long been the most conservative of China's biggest airlines, more interested in defending its strong Shanghai market than intruding into rivals' territory. China Southern Airlines, on the other hand, has been forced by the relative low demand at its Guangzhou home to look hungrily elsewhere.

In setting out priorities for 2017, the two carriers are sticking to those patterns. China Eastern is placing its new widebody capacity at Shanghai, while China Southern is renewing its emphasis on developing at Beijing, the home of the other big carrier, Air China.

"We will put maximum effort into the creation of a Beijing hub operation," senior China Southern managers told their staff during a meeting that set out plans for this year. The airline had 28 aircraft, mostly widebody types, based at Beijing Capital International Airport in the second half of 2016, out of a nationwide fleet of 493. But it will eventually base 200 aircraft at the airport being built in the city's southern suburbs, the managers announced. The new airport is due to open in 2019, with China Eastern Airlines as the other anchor operator.

Meanwhile, China Southern has been busy adding capacity and routes at Capital. Its home airport, Guangzhou Baiyun International, suffers from having a smaller local population than Air China and China Eastern have at Beijing and Shanghai, respectively. Its southern location also makes it an unsuitable gateway for most Chinese long-haul services, and it is up against powerful competition from nearby Hong Kong International Airport and Cathay Pacific Airways.

Baiyun International will be offering services to Cairns, Australia, and Vancouver with an extension to Mexico City this year.

Since the Civil Aviation Administration of China has announced no

Ten A330s will leave the China Eastern fleet in 2018, but new aircraft of the same type are arriving. application for such services, they are unlikely to begin for some months.

China Southern's senior managers told the meeting they would create a unified hub with Baiyun and Shenzhen Baoan International Airport. It is unclear how this can realistically be done. The two facilities are 100 km (60 mi.) apart with no fast rail line linking them. But such boilerplate language about the two airports working together is likely to appeal to the government of Guangdong, the province in which they are located.

China Southern also has a base at Urumqi Diwopu International Airport in the country's far northwest. It was announced at the meeting that a base would develop as a hub for services to and from Central and Western Asia. In doing so, it would exploit the government's Belt and Road policy for promoting international economic ties, including those with adjacent countries. The other China Southern base is at Chongqing Jiangbei International.

China Eastern Airlines, meanwhile, says it will add four Boeing 777-300ERs and seven Airbus A330-300s to its fleet in 2017, concentrating the additional widebody aircraft at Shanghai. As 27 A320-family aircraft and 34 Boeing 737s also enter service with China Eastern and subsidiary airlines this year, the group will prepare to retire 10 A330s in 2018, says a company official.

All the new A320-family aircraft this year will go to the group's core com-

pany, China Eastern Airlines Corp. Ltd., and its branches. All the new 737s will join the fleets of its six subsidiary airlines, the group says. The subsidiaries include China Eastern Yunnan Airlines, China United Airlines and Shanghai Airlines.

Allocation of Airbus and Boeing narrowbody types to separate fleets adheres to established China Eastern group policy. Another company official says the group will do the same with widebody aircraft. Of 15 Boeing 787-9s that will begin arriving in 2018, 10 will go to Shanghai Airlines and five to China Eastern Yunnan, says that official. The core company's widebody fleet, meanwhile, will be consolidated on 777s, A330s and, beginning in 2018, A350s.

Seven A330-300s and three A330-200s will leave the fleet in the first seven months of next year, says the first official. Those aircraft have like-for-like replacements. China Eastern agreed to take 15 A330s from orders for 75 that the government orchestrated in 2015. This year's seven new A330-300s must have been included in that agreement. The other eight should come close behind them, since Airbus is replacing the A330-300 with the A330-900.

Two China Eastern Airlines Corp. Ltd. branches, based at Chengdu in the southwest of the country and Xian in the northwest, have benefited from a decision to strengthen their 2017 allocations at the expense of the Shanghai operation. The originally planned three A320-family aircraft destined for the Xian operation will be joined by one more and an A330-200 will be transferred from Shanghai. Transfer of the widebody model implies a plan for a long-haul service from Xian this year.

-Research by Ryan Wang



# **Printing Advances**

Oxford Performance Materials targets turbofan structures for 3-D-printed composites

#### Graham Warwick and Michael Bruno Washington

erospace manufacturers have long used polymer 3-D printing for rapid prototypes or low-strength production parts such as ducting, but the need for load-bearing structural components has pushed the industry to qualify metal additive manufacturing processes using highstrength alloys.

But just as reinforced composites have grown in capability over the decades to gain a major share of airframe structures, polymer additive manufacturing is evolving. Oxford Performance Materials (OPM) has secured a Boeing contract to supply 3-D-printed components for the CST-100 Starliner manned spacecraft that are large, complex, composite and structurally loaded.

"Some parts are highly loaded," says Bernie Plishtin, chief business development officer. The company's Oxfab additive manufacturing process uses a high-performance thermoplastic, polyetherketoneketone (PEKK), reinforced with short carbon fibers. OPM says it is the first to apply 3-D printing to PEKK, which has high resistance to heat and can withstand high mechanical loads.

South Windsor, Connecticut-based OPM uses carbon fiber from Hexcel, and the composite materials producer has invested an additional \$10 million in the company, taking its total to \$25 million. "Hexcel's follow-on investment will further enable OPM to expand capacity to meet rapidly growing market demand . . . in aerospace and other industries," the company says.

Oxfab parts will be used in three areas within the CST-100, which is designed to carry up to seven crew to low Earth orbit. One is the air revitalization system, says Plishtin. OPM has begun shipping production parts to Boeing for installation in the spacecraft, which is scheduled for its first unmanned orbital test flight in June 2018, followed by a crewed flight in August 2018.

"From our earliest discussions with Boeing, they stressed the need to

see significant reductions in weight, cost and lead times in order to consider replacing traditional metallic and composite parts with a new technology for their space program," says

Larry Varholak, president of OPM Aerospace and Industrial, the company's 3-D-printing unit.

"Boeing has demanding requirements for manned spaceflight. We worked with them for many years and met every test point to get on the Starliner. But that just gets us past the performance part," says Plishtin. "The real benefit is in time to delivery, cost reduction and the ability to address design changes quickly."

Introducing chopped carbon fiber into the PEKK "alloy powder" significantly reinforces the thermoplastic and makes the material conductive. Components are 3-D-printed by laser sintering—melting the powder with a laser beam to produce a part layer by layer—and the material is "machine agnostic," he says. So far, the technology has been qualified with one manufacturer's laser sintering machine.

With 3-D printing, complex parts can be produced without tooling or touch labor. "We can comingle shape and complexity with no negative consequences," Plishtin says. OPM also recycles the unused powder to reduce cost. "Only 10-12% of the powder in the bed is used in each run. The other 85%plus is unused powder that we can recycle," he says. Oxfab is qualified for one recycle, but OPM is working with a "major prime" to qualify the material to be recycled up to three times, and possibly more. "The second recycle will be qualified within this quarter," says Plishtin.

The next step is to apply Oxfab to commercial aircraft, and the company is initially targeting thrust-reverser

#### Structurally loaded duct in the air revitalization system is among Oxfab 3-D-printed composite parts for Boeing's CST-100

cascades and fan exit guide-vanes on turbofans. "These are secondary structures that are loaded, and historically have tremendous touch-labor content," he says. "We can replace a hand-layup composite cascade for a 50% reduction in cost by eliminating that labor."

In addition to eliminating hand layup and reducing the raw material required, 3-D printing removes the need to machine the cascade to its final shape. "We just machine the attachment holes to the positional tolerance," Plishtin says, adding that cascades can be produced as a single part, eliminating attachment hardware, and they offer weight savings over aluminum or magnesium castings.

"We are talking to engine manufacturers," he says. OPM is developing technology to nickel-plate the fan exit guide-vanes for erosion protection. "We can 3-D-print a six-pack of vanes as one part and nickel-plate the entire structure." Plishtin says the 3-D-printed structural vanes have the density of aluminum and mechanical properties "between titanium and the highestperformance aerospace aluminum."

OPM uses Hexcel's AS4 carbon fiber but is now working to incorporate the company's IM intermediate-modulus and HM high-modulus fibers into Oxfab. "We have aggressive research and development spending," says Varholak. The company is also gearing up for high-volume 3-D printing of engine components. "We have nine machines and are facilitized for 40. We are growing rapidly," he says.

## Saudi's New Sword

# Boeing resolves flight-test issues to deliver advanced Eagles

#### **Guy Norris Los Angeles and Tony Osborne London**

saudi Arabia has begun inducting its first Boeing F-15SAs, the most potent variant of the Eagle ever developed.

At \$29 billion, the program to build 84 fresh new F-15SAs and at the same time rebuild the kingdom's 68 remaining F-15S Strike Eagles to SA-model standard, is the most valuable Foreign Military Sales contract in U.S. history and will continue the Royal Saudi Air Force's (RSAF) transformation program.

The F-15SA is among a long list of new types to join the refreshed Saudi inventory, which includes Eurofighter Typhoons, BAE Hawk Mk. 165 jet trainers, Lockheed Martin KC-130J tankers—and it provides a significant leap in combat capability. The aircraft incorporates the APG-63V3 active, electronically scanned array radar, an advanced digital electronic warfare and radar warning suite, and updated cockpit displays. It also carries the Tiger Eyes infrared search-and-track system.

But even with a hefty price tag, development of the F-15SA has not been without problems. Key to delivering its new capabilities is a model-based flyby-wire (FBW) flight control system, introduced to offset the destabilizing effect of adding two outboard underwing weapons stations, 1 and 9. The FBW system is also designed to make it easier for Saudi pilots to convert from conventionally controlled F-15s, and it lowers overall aircraft weight, improves reliability and increases sortie generation. However, development of the system has proved to be unexpectedly problematic.

Although Boeing has consistently managed to keep a tight lid on news about the program and its difficulties, the company did acknowledge that challenges were encountered early on during initial envelope expansion tests, which at one point became so problematic that they were suspended in the spring of 2013.

It turns out a significant part of the delay was linked to unanticipated issues encountered during flights to explore the envelope at high angles of attack and Mach numbers. According to program sources, pilots unexpectedly encountered wildly varying yaw rates at higher alpha that were independent of whatever configuration was flown, and that in some cases made further testing unsafe.

In response, Boeing modified the aerodynamic model on which the FCS was based and repeated the tests to compare against the F-15E and determine the cause. Investigations identified a spin recovery mechanism that had been developed for the F-15E and was being emulated by the spin recovery logic of the F-15SA control system.

As the F-15SA system was modeled on the F-15E and overall mold lines and mass properties were so similar between the two versions, developers had seen no requirement for the cost and risk of fitting a spin-recovery chute. Consequently, it was decided just to test spin resistance on the Saudi aircraft rather than conduct actual spin departures or departure recoveries.

Further analysis revealed that as a result of the varying approach to spin testing there was a subtle but key difference between the high alpha test configurations of the F-15E and the F-15SA.

To minimize the danger of the spinrecovery chute tangling in the vertical tails in the event of a deployment, re-

#### There is little to tell an F-15SA apart from an F-15S, with the exception of new warning system antennae fitted on either side of the rear cockpit.

SAUDI PRESS AGENC

searchers discovered that the booms on the leading-edge tips of the vertical tails had been temporarily removed from the F-15E during the original high-alpha and spin-test program more than two decades before. The booms are designed to increase flutter margin by minimizing structural modes at high Mach numbers and are part of the standard configuration for all variants including the F-15SA.

Sources say the F-15SA test team based its evaluation plan on the assumption that these tests had later been completed in the 1990s. However, it turned out the test points had never been finished, resulting in an inaccurate aero model of high alpha and Mach number characteristics and the unexpected F-15SA flight-test findings.

These issues are believed to be one of the primary causes of a nearly twoyear delay in the program, first deliveries of which had been expected to start in late 2014 or early 2015. However, social media reports suggest there has also been some dissatisfaction by the RSAF over the specifications and capabilities of some of the early delivery aircraft, and so it apparently elected not to take delivery on at least one occasion. With aircraft rolling off the production line, Boeing was forced to temporarily store them until deliveries could get underway.

Aircraft finally began arriving in Saudi Arabia last December, when a batch of four aircraft flown by Saudi aircrew flew in via the UK and were immediately transferred to 55 Sqdn., the unit chosen as the F-15SA training unit.

Among the first four to be delivered were the first two F-15Ss converted to the F-15SA standard by Boeing. The rest of the fleet will be converted incountry by Riyadh-based Alsalam Aircraft Co., which also builds the updated cockpit section and main wing of the new model as well as some of the weapon pylons. A second batch, consisting of six aircraft, was due to be delivered in February.

The aircraft was formally inducted into the RSAF on Jan. 25 during a ceremony at the King Faisal Air College in Riyadh attended by senior figures in the Saudi government and royalty. •

This concept image shows four XQ-222s in an attack formation releasing 250-lb.-class Boeing Small-Diameter Bombs.

## **Drone Strike**

Long-range attack UAVs being developed from aerial targets

#### **James Drew Washington**

The dawn of the limited-life combat drone is rapidly approaching as Kratos Defense & Security Solutions Inc., a rising star of the Pentagon's so-called "Third Offset" strategy, doubles down on development of a \$3 million V-tail UAV, internally designated XQ-222.

Kratos specializes in building subscale aerial targets designed to mimic Russian and Chinese weapons and is now adapting them for real-world combat use by the Defense Department as armed, autonomous aircraft that can be produced in great quantities at a fraction of the cost of a manned fighter jet. These machines are being pursued under the Pentagon's Third Offset, which places many small bets on promising technologies that have the potential to revolutionize digital-age warfare in the U.S.'s favor.

The model XQ-222 is being developed under a 30-month contract with the Air Force Research Laboratory, called the Low-Cost Attritable Strike UAS Demonstration (LCASD). Kratos won the contract in July against seven competitors, including some of the largest aerospace companies in the world.

The San Diego-based company is confident of moving into flight testing and demonstration by the May 2018 target. "We are taking high-performance target drones and technology that exist today, and in two years we'll develop, build and demonstrate a combat aircraft," Kratos CEO Eric DeMarco said at the Needham Growth Conference in New York in early January.

The company says the XQ-222 is a "very large" aircraft with an approximate range of 3,000 mi. (1,500-mi. return combat radius) carrying a 500-lb. payload. This would allow it to penetrate eastern China or North Korea on one-way missions from Andersen AFB, Guam.

The aircraft is being developed by Kratos's unmanned systems division, acquired as Composite Engineering of Sacramento, California. The aircraft's electronics, avionics and commandand-control architecture are produced in-house, while subcontractors work on the parachute recovery mechanism and efficient turbojet engine.

Target drones are designed to mimic adversary aircraft and cruise missiles, conducting sophisticated maneuvers from high to low altitudes. By adding targeting sensors and internal weapons, Kratos has created flying weapons of war, capable of dropping 250-lb. Small-Diameter Bombs on surface-toair missile and radar sites as part of a first wave attack, when the chances of being shot down are the highest.

The turbojet-powered drone features a low-signature airframe and topmounted air intake with canted wings, akin to the General Atomics Aeronautical Systems Avenger. The concept image provided by Kratos (see above) is the first depiction of the company's LCASD proposal released publicly. It has a dash speed of Mach 0.85 with runway-independent, rocket-assisted takeoff and parachute recovery.

KRATOS CONCEPTS

If successful, DeMarco says, LCASD could become a significant growth engine. Kratos is investing more than \$40 million of its own money into the project compared to the government's \$7.3 million commitment. The total value could be about \$100 million if the government awards additional contracts for spiraled development work. The LCASD program was created with the intent of demonstrating an unmanned combat aircraft valued at up to \$3 million apiece for batches of 99 per year, or \$2 million for annual orders of 100 or more.

DeMarco says the investment in LCASD comes on top of \$50 million over three years to develop the Unmanned Tactical Aerial Platform-22 (UTAP-22), based on the its BQM-167A subscale aerial target, produced for the Air Force. The aircraft has a range of 1,400 nm and 3 hr. of endurance, with a ceiling altitude of 50,000 ft. It can carry 100 lb. under each wing and has a 500-lb., 8.3-ft.<sup>2</sup> internal payload capacity.

A Navy AV-8B Harrier demonstrated its ability to control a UTAP-22 "wolf pack" with test flights at China Lake, California, in late 2015. The high-performance combat drones will serve as "loyal wingmen" for manned fighters and bombers, cooperatively supporting missions fully or semiautonomously.

Last year, the Pentagon's Defense Innovation Unit-Experimental (DIUx) awarded Kratos \$12.6 million to fly a "swarm" of UTAP-22s during a major military exercise, the first governmentsupported flight demonstration since late 2015. The trial is being sponsored by the U.S. Strategic Capabilities Office and Strategic Command (Stratcom).

"A swarm will be flying in a major military exercise in the second half of this year," DeMarco says. "We're hoping once we successfully demonstrate it, in the near term, we are going to be getting production orders for this aircraft in the \$3 million range."

Last year, the company also secured a place on the DARPA Gremlins program, as well as another classified target or combat drone program. Gremlins will demonstrate the launch and recovery of a swarm of low-cost unmanned aircraft with different mission-specific payloads from the Lockheed Martin C-130. Kratos is developing a scaled, low-cost version of UTAP-22 for the program.

If Gremlins ever transitions into a program of record, the lightweight drones could be dropped from cargo aircraft or bombers on high-risk missions where the loss of several vehicles is expected. They would host unique payloads such as surveillance, decoy, electronic attack or explosive warheads to overwhelm an adversary's defenses.

Gremlins Phase 1 contracts valued at about \$4 million each were awarded to Kratos, Dynetics, General Atomics and Lockheed. The companies are now vying for Phase 2 and 3 contracts, valued at \$20 million and \$33 million, respectively, for proof-of-concept demonstrations. DeMarco says production quantities could be in the "hundreds of thousands" of aircraft at about \$700,000 each, if adopted.

A downselection to two contractors is expected in March for additional concept maturation and design, followed by the selection of one vendor in late 2017 or early 2018 for the flight demonstration. "We believe the No. 1 reason we won this program is our airplane," DeMarco says. "I am more confident than ever that our aircraft is going to be moving on into Phase 2 and eventually Phase 3 [of Gremlins]."

Kratos's unmanned systems division will approximately double in size over the next two years on the back of two aerial target programs that are transitioning into low-rate initial production, once the Pentagon's fiscal 2017 defense bill is signed. DeMarco identified those products as the Navy BQM-177A, overseen by Naval Air Systems Command's target and decoy office, and a target classified program. Kratos's target drones are the basis for its high-performance unmanned combat aircraft push.

The BQM-177A is derived from the BQM-167X, incorporating a new highwing fuselage and MicroTurbo TR-60-5+ small turbojet engine. It is being designed to mimic the latest adversary weapons to stress U.S. ship defense systems. The Air Force BQM-167 is in its 13th year of production, and Kratos anticipates another sole-source contract this year for years 14-16. Meanwhile, production continues for the MQM-178 "Firejet" for the U.S. Army and several international customers.

Approximately 60% of Kratos's revenue comes from U.S. government programs. The company expects to grow to \$700-720 million in 2017, from \$660 million in 2016, driven mostly by the government's investment in Third Offset-type technologies for high-end combat operations. Kratos was hit hard by the Budget Control Act of 2011 but is bouncing back as the military invests in futuristic technologies such as autonomous aircraft and high-energy lasers, as well as space resiliency systems.

Last year. Kratos won contracts to produce the Air Force's KC-46 high-fidelity maintenance trainer (worth \$20 million initially) and the Marine Corps' common rotary-wing aircrew trainer (\$54 million). It also won a contract to monitor satellite radio frequency interference for Stratcom, valued at \$6.2 million. Kratos's "crown jewel" is its satellite communications business, which provides satellite command and control as well as radio frequency monitoring and threat geolocation via a global network of ground infrastructure. If something attempts to interfere with, jam or maliciously alter U.S. military or commercial satellite transmissions, Kratos can geolocate that threat, allowing the Defense Department to "neutralize it one way or the other," DeMarco says.

"There's a \$5 billion plus-up to protect U.S. space assets from potential adversaries such as a Russia or China, and that's providing a tailwind for this business," he says. "While 2016 was a good year, 2017 will be a great year. We are going to knock it out of the park with some of these programs." ©



# **Signaling Intent**

# If China is developing a naval AEW, a few catapult-launch carriers must be coming

#### **Bradley Perrett Beijing**

ometimes a grainy photograph can reveal a great deal. One showing a mockup of a Chinese naval airborne-earlywarning (AEW) aircraft similar to the Northrop Grumman E-2D Hawkeye has appeared, suggesting that Beijing plans a substantial fleet of aircraft carriers.

The probably intentional revelation of the mockup comes as China's second aircraft carrier, outwardly similar to the first, takes shape at Dalian in the country's northeast.

High-performance aircraft will take off from that ship by hurtling from a ski jump, as they do from China's first carrier. But the propeller-driven aircraft indicated by the mockup would probably need catapults for safe and effective operation. So development of the aircraft, if confirmed, would imply plans to build more carriers. Indeed, any such aircraft program would be hard to justify unless China expected to operate several catapult-launch carriers, probably building its fleet of flattops to six or more.

The blurry photograph on a Chinese microblog account shows the AEW mockup on the top of a well-known building in Wuhan that has its roof laid out as a carrier flight deck. That location and the presence of supporting stands indicate that the object is not a flyable aircraft. A Flanker mockup on the deck provides a reference for estimating dimensions—assuming that both models are at 1:1 scale.

Accordingly, the twin-engine AEW aircraft appears to be roughly 18 m (59 ft.) long, compared with the 17.5-m Hawkeye. Proportions look similar, but wingspan cannot be estimated with any precision. The diameter of the dorsal radome is probably not much different from the 7.3 m of the Hawkeye, so antenna sizes will be about the same. The radome looks circular, meaning it is designed to rotate.

As with the Hawkeye, the designers have held down height, a critical issue in carrier operations, by dividing the vertical tail area among several fins; there appear to be three, compared with four on the Hawkeye. China has been working on a turboprop of 3,800 kW (5,100 hp), the WJ16, as a successor to the old WJ6C, the local version of the old Ivchenko AI-20 from Ukraine, at the same power. The WJ16 and WJ6C would both suit the carrier AEW airccraft. Indeed, the Hawkeye's Rolls-Royce T56 has the same output. The engine power available to the Chinese is another reason for judging that their AEW is of Hawkeye size.

Turbofan propulsion would have offered higher speed—of limited value for an aircraft that would not fly far from its ship—and less endurance. Even if the navy preferred a turbofan, it would have to worry about how long the immature Chinese aero-engine industry would take to develop a reliable and efficient one. The WJ6C, on the other hand, is ready and proven. The development status of the WJ16,



CHINESE INTERNET

The configuration follows the Hawkeye's in other ways: The wing is mounted above the fuselage, with a dorsal inlet for avionics cooling just ahead of it, and the main landing gear appears to be housed in the rear of the underslung engine nacelles. A difference is that a pylon, rather than an open frame, carries the radar antenna. Tarpaulins obscure the nose shape and the top of the fuselage around the wing and radar pylon.

Although a conservative inclination to follow the successful Hawkeye design could have been a factor in choosing the configuration, the Chinese developers may have struggled to find anything better—at least without dispensing with a crew. Given the mission, a requirement for a crew of system operators, a need for a large antenna and the limitations of carrier hangar heights, the Hawkeye configuration may well have seemed to be the only sensible choice.

Two suitable engines are available.

#### The mockup of the Chinese shipborne AEW perched on the carriershaped roof of a building in Wuhan.

part of a proposed family of engines, is unknown, but there is reason to think it is a priority: It would usefully replace various versions of the WJ6 on several Chinese aircraft types.

Shaanxi Aircraft is a likely home of the airframe program, since that Avic unit developed the KJ-200 AEW from the WJ6-powered Y-8. The KJ-200's radar has an active, electronically scanning array, according to Chinese media, so the same technology could be expected in the naval AEW.

An AEW would improve China's aircraft carriers in what the U.S. Defense Department sees as Liaoning's possible role, "fleet air defense missions, extending air cover over a fleet operating far from land-based coverage." For that purpose, Liaoning carries mainly the J-15 fighter, a Flanker copied from the Russian carrier-borne Su-33. AEW

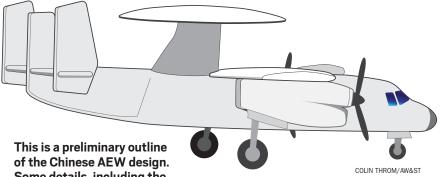
aircraft can also provide critical warning of attack by anti-ship missiles.

Photographs of an Avic Xian Y-7 commercial transport adapted as a naval AEW model have previously appeared. With a span of 30 m, the Y-7 type did not look suitable for flying from a deck and still less for landing on one.

A mockup does not indicate much progress beyond preliminary design, so there can be no assurance that the new AEW design will go into production or even that it has entered fullscale development. Still, revelation of the mockup is likely to be a deliberate move by the Chinese navy to signal intentions.

The AEW is probably not urgently required. China is working on catapults for launching naval aircraft, but even the second carrier, with a ski jump, is not due to enter service until ported to the island's parliament in 2015 that China was building a third carrier, at Shanghai. This has not been confirmed. But the catapult work and now the appearance of the AEW mockup strongly suggest that a third carrier is planned. Indeed, neither the catapult nor AEW effort would be remotely justified by just one catapult-equipped ship, so Chinese planning must include several more carriers.

This point is underlined by the availability of an inferior but quite workable and much cheaper alternative to developing a naval AEW airplane: adapting a helicopter. Avic has tested its AC313 helicopter at 8,000 m, an altitude that offers almost as distant a horizon as enjoyed by a Hawkeye at its 11,300-m ceiling. A naval AEW aircraft can form the basis of a cargo aircraft for carrier operation but, again, a helicopter can



## Some details, including the nose arrangement, are speculative.

2020, according to a provincial official who in 2014 revealed the beginning of construction.

That ship, Shandong, is largely following the external arrangement of the first, Liaoning, which was commissioned in 2012. Liaoning, laid down by the Soviet Union as a sister to what is now the Russian carrier Kuznetsov. was bought unfinished from Ukraine and completed at Dalian.

The latest photographs of Shandong under construction show the ship looking structurally complete but still shrouded in scaffolding and equipment. Floating out of its building dock by the end of next year seems likely.

The British aircraft carrier Queen Elizabeth, larger than Liaoning and Shandong, was floated out in 2014. It is due to be commissioned this year. If Shandong also needs three years between floating out and commissioning, it should be in service in 2020 or 2021.

Taiwan's intelligence services re-

be a limited but realistic substitute.

If the Chinese navy is rejecting these alternatives, then it very much wants to operate catapult-equipped carriers. The reasoning is that a catapult imparts greater velocity than a departing aircraft can achieve by running down the deck unassisted, even if the acceleration distance is extended ahead of the ship by the ballistic trajectory induced by a ski jump. Aircraft using catapults can therefore carry more fuel and weapons.

Conceivably, Liaoning and Shandong could be retrofitted with catapults, helping to justify the AEW and launchtechnology programs. Many U.S. and British carriers of World War II were so retrofitted in the 1950s. But those two Chinese ships would need major structural changes, because each has a ski jump formed by the shape of the hull rather than built on it.

Also, Shandong, unlike Liaoning, will probably lack the steam propulsion plant needed to feed a conventional

catapult. Shandong will have a new propulsion system, according to Cao Weidong, a member of the Chinese Navy's Academic Research Institute. It will not be nuclear. The configuration of HMS Queen Elizabeth looks likely-diesel cruise engines for cruising supplemented by gas turbines for higher speeds. China is also working on electromagnetic catapults, which any kind of propulsion machinery can drive if generators are provided, but U.S. experience suggests that the technology is not easily mastered.

The defense ministry said at the end of 2015 that Shandong would displace around 50,000 metric tons. A ship's displacement depends greatly on the loading condition, however. Liaoning displaces about 60,000 metric tons fully loaded, so Shandong would be close to that even if its unladen displacement were 50,000 metric tons. A reduction in size for successive ships of any particular type would be surprising in the growing Chinese navy.

U.S. carriers displace about 100,000 metric tons at full load. Queen Elizabeth and its sibling, Prince of Wales, are designed for about 70,000 metric tons in the same condition.

The internal arrangement of Shandong is supposed to be quite different to Liaoning's, but details are unavailable. One external change visible during construction is that the antennae of the main radar are mounted higher on Shandong's island than on Liaoning, affording a longer warning time for missile attack.

Shandong's entry into service will help ensure one carrier is available even when one is being refitted, notes analyst Roger Cliff of the Center for Naval Analyses. Liaoning has been declared operational, though Cliff points out that such a status can be elastically defined. A carrier is most useful when deployed far from home, but a particular Chinese problem is poor skills in maintenance at sea, he adds. Repairs are generally done in port.

If China does plan to operate six or more aircraft carriers, the pace of construction will have to pick up, since Shandong is at least eight years behind Liaoning. Even if the interval between deliveries falls to five years beginning in the mid 2020s, the sixth unit would not be commissioned until around 2040, by which time Liaoning could be approaching the end of its service life. 🐼

# **Looking Abroad**

Wildcat, Seahawk and NH90 line up for Seoul's naval order

#### **Bradley Perrett Beijing**



REPUBLIC OF KOREA NAVY

n South Korea, a country highly inclined to build weapons domestically, the temptation to use the Korea Aerospace Industries (KAI) Surion helicopter in a maritime role has been strong. The Surion is about the right size and already in production for the army and marines. Adding a naval order would cut its unit costs and add jobs.

But South Korea has in the end decided to import its next batch of maritime helicopters. The Leonardo AW159 Wildcat, now in service with its navy, looks well-placed to win the order for 12 helicopters, which could lead to contracts for a further 42. Irregularities in the acquisition of an earlier batch of Wildcats may present problems for Leonardo, however.

The Defense Acquisition Program Administration (DAPA) expects the NH Industries NH90, built mainly by Airbus, and the Sikorsky MH-60R Seahawk, to also be candidates. DAPA requires deliveries in 2020-22.

The debate over whether to import has held up the Maritime Operational Helicopter 2 (MOH 2) program. Three successive assessments conducted by the defense ministry since 2012, beginning with one for the preceding MOH 1 order, have found that only foreign helicopters should be considered.

When the MOH 2 order came up for consideration, KAI's political backers insisted on the second assessment. Then a third was ordered after accusations of tampering by the navy and the prosecution of a lobbyist engaged by what was then Finmeccanica, now Leonardo. DAPA, the ministry's purchasing office, has made the decision final: South Korea will import.

Finmeccanica won the MOH 1 competition in 2013 and delivered eight Wildcats in 2016. The new program will fill the navy's original requirement, dating to 2007, for 20 MOH helicopters.

DAPA says MOH 2 will play an important role in facing the threat of North Korean ballistic missile submarines. But no such threat was in prospect when the navy first set out its MOH requirement, so the agency is evidently exploiting a current public concern to build political support for the program. A North Korean ballistic missile, presumed to be a KN-11 submarine-launched weapon, flew about 500 km (300 mi.) last August, following a trajectory that implied a full range of 1,000 km. The KN-11 is not thought to be operational.

> The winner of MOH 2 should enjoy a competitive position to replace the South Korean navy's Lynx helicopters. Leonardo predecessor company Westland delivered 24 Lynxes in the 1990s; 23 remain in service. Later the navy will need 18 more rotorcraft, because its fleet of destroyers and frigates is growing, with 23 ships programmed to enter service in 2013-20.

South Korea chose the Leonardo AW159 Wildcat for its MOH 1 requirement. KAI is building the Surion for the army, marines and civil authorities.

With a gross weight of 8.7 metric tons (19,200 lb.), it is larger than the Wildcat but smaller than the MH-60R and NH90. For the maritime role, KAI proposed to fit a dipping sonar, sonobuoy dispenser, anti-ship missiles, torpedoes and foldable main rotor and tail. Airbus would have assisted in development. The Surion does not fit the hangars of some ships, but KAI offered to modify them.

There have been irregularities in the MOH 1 and 2 programs. The chief of the naval staff during the MOH 1 competition, Choi Yoonhee, was jailed in November 2016 for accepting a bribe from a lobbyist engaged by what was then Finmeccanica. The court did not, however, find that he had pressured subordinates to favor the AW159.

In February 2015, the newspaper *Dong-A* reported that the navy had tampered with the second assessment of the choice between importing or developing a maritime Surion. Local development would delay MOH 2 deliveries by a year, according to the first draft of the assessment report. Following input from the navy into what was supposed to be an independent study, the estimate was changed to the six years in the final version.

Then the head of the veterans affairs ministry, Kim Yang, was arrested in July 2016 and charged with receiving an illegal lobbying fee of 1.4 billion won (\$1.2 million) from Finmeccanica during the MOH 1 competition. A court sentenced him to four years in jail for the crime in December 2016. Leonardo declines to comment on the court cases except to note that it is not involved in any legal proceedings in South Korea.

Development and production of Wildcats under the 589 billion won MOH 1 program ran into some difficulties. The type needed addition of a dipping sonar, but SBS Television reported last year that the winch for that equipment had not met specifications, so the price paid had been reduced by 10 billion won. DAPA also required changes to the automatic flight-control system shortly before deliveries began.

Debates over whether to import weapons or develop locally are unusually common and fierce in South Korea. In a country that has for decades fostered domestic industries as it has advanced economically, local arms manufacturers enjoy considerable public and therefore political support. But some politicians, and often the armed forces, oppose the use of the defense budget for industrial development.

# **Tanker UAV**

# The U.S. Navy is working to develop a carrier-based refueling drone

#### Lara Seligman Washington

s adversaries develop sophisticated capabilities that force U.S. aircraft carriers to operate farther from enemy shores, the U.S. Navy is taking steps to field a carrier-launched unmanned tanker that will extend the range of the carrier air wing.

The service has been working on a concept of operations for its first carrier-based UAV for years, but the notional platform has gone through several vastly different iterations. What began as a surveillance and strike UAV was eventually retooled as a tanker designed to extend the legs of manned fighters such as the F/A-18 Super Hornet.

The Pentagon may finally be moving forward on the new platform. Planners last year settled on a Carrier-Based Aerial-Refueling System (CBARS), or MQ-25, primarily focused on providing organic refueling capability to the carrier air wing. In addition, Navy officials say they will consider the extent to which CBARS can also incorporate intelligence, surveillance and reconnaissance (ISR) as a secondary mission.

"The system will be a critical part of the future [carrier air wing] and will enhance carrier capability and versatility for the Joint Forces Commander through the integration of a persistent, sea-based, multimis-

#### The U.S. Navy tested the X-47B Unmanned Combat Air System demonstrator onboard the aircraft carrier George H.W. Bush in 2013.

sion aerial refueling Unmanned Aircraft System," says Capt. Beau Duarte, MQ-25 program manager.

The Navy last year awarded four companies—Boeing, Lockheed Martin, Northrop Grumman and General Atomics—concept refinement contracts that will inform an upcoming request for proposals (RFP) for

engineering and manufacturing development. The RFP is expected this summer, with a contract award following in 2018.

As President Donald Trump signals he wants to significantly boost defense spending to improve military readiness, the Navy may be feeling even more pressure to fast-track the new platform. Sen. John McCain (R-Ariz.), the powerful chairman of the Senate Armed Services Committee, urged the Navy to accelerate the MQ-25 to reach initial operational capability in the next five years, according to a recent white paper of recommendations for the five-year defense plan.

"As advanced, long-range air defense systems proliferate, the carrier air wing needs aircraft with greater range that can penetrate advanced defenses and conduct strike and intelligence missions," McCain writes in the white paper. "The Navy must proceed rapidly to develop a carrier-based unmanned aircraft to perform these missions."

The Navy has not responded to the white paper, according to a service spokeswoman. But the concept of an unmanned refueling/ISR platform presents a problem: The design elements required for a tanker and a surveillance aircraft are fundamentally at odds. An ISR aircraft needs to fly at high altitudes for long periods, so a large wingspan and efficient engine design are essential. ISR assets generally do not carry much fuel internally, as this adds weight to the platform. By contrast, a tanker must carry enough fuel for all of the carrier air wing's strike aircraft, requiring a larger engine.

Naval aviation planners and industry are working on finding the "sweet spot" for the MQ-25 to fulfill both missions, Vice Adm. Mike Shoemaker, commander of Naval Air Forces, said during an event in Washington last year.

Also at issue is how stealthy the MQ-25 needs to be for the future operating environment. Although a recent top-level Pentagon review concluded survivability would not be a key requirement, the Navy is seeking a way to capitalize on certain existing "shapes" to make the platform less vulnerable, according to Shoemaker.

"If you look at where we've been with many of the industry partners, there are some shapes that they've designed already that help in that survivability piece," says Shoemaker. Although he did not mention specific industry players, he says there are several existing designs that could serve as a baseline for the MQ-25. The Navy will likely consider the four proposals offered by General Atomics, Boeing, Lockheed Martin and Northrop Grumman for the previous iteration of the carrier-based UAV, the Unmanned Carrier-Launched Airborne Surveillance and Strike program.

The competition for the MQ-25 will likely come down to a



U.S. NAVY

traditional wing-body-tail design such as General Atomics' and Boeing's proposals, or the tailless, flying-wing airframe offered by Lockheed and Northrop, shaped much like the U.S. Air Force's B-2 stealth bomber.

Shoemaker suggests that the Navy is at least considering a stealthy shape for the MQ-25, arguing that a tanker forward-deployed to hostile territory could be vulnerable. "If you look at the way you would conduct mission tanking, you have got to push something out ahead of everybody to get it on station so you can launch your other airplanes," he says. "If you send the MQ-25 out by itself, and it does not have survivability, you have got to know where you are sending it so it's not going to get shot down."

While Shoemaker cautions that 'stealth tanker,' those two don't go together on MQ-25," there are steps the Navy could take to evolve a tanker UAV into a survivable strike platform. It would be relatively easy to modify a tanker to carry weapons—simply swap out the fuel carried internally for bombs. And if the MQ-25 is based on a flying-wing design already optimized for stealth, the Navy could add a radar-absorbing coating to maximize survivability.

# **Eye-Catching**

# Indian fighter requirements for two services have many suitors

#### Jay Menon and Bradley Perrett Bengaluru, India

he Indian air force has 33 fighter squadrons but reckons it needs 42, mostly to counter China. To cover that gap while containing costs, the government has specified that the next air force fighter should have one engine. It may need 200 units of the chosen type.

Its navy, meanwhile, has dumped a proposed carrier-based version of the Hindustan Aeronautics Ltd. (HAL) Tejas fighter, complaining that the indigenous type is overweight. Moving faster than the air force, it has issued a request for information for an order for 57 shipborne fighters, plus options on more. Together, the air force and naval requirements represent a most eye-catching opportunity for the world's fighter-makers.

That is especially so for Saab, which alone has hopes of snagging both contracts. Its JAS 39E/F Gripen has just one engine, so only it and the Lockheed Martin F-16 Fighting Falcon qualify for the air force requirement. Saab will also offer its proposed carrier-based Gripen M to the navy, competing against Boeing (proposing the F/A-18E/F Super Hornet), Dassault (with the Rafale M) and United Aircraft Corp. (UAC), offering an upgraded MiG-29K.

For Lockheed Martin, the air force requirement offers a chance to extend F-16 production strongly into the 2020s. Indeed, the company has proposed that final assembly would move to India. That looks all the more practicable because Defense Minister Manohar Parrikar has said the air force program could result in orders for about 200 fighters. Also, the F-16 is now only an export product; the U.S. Air Force has ceased ordering the type.

UAC is not giving up on the Indian air force requirement either, reasoning that the government could change its mind and see a budget saving in choosing the MiG-35, the latest version of the type that began as the MiG-29 and is called Fulcrum by NATO. The MiG-35 demands less than half the acquisition cost of its Western rivals, says a Russian industry source whose company would benefit from India choosing the type. Moreover, waiting for the customer to change its mind is not an entirely unrealistic approach in India, where the government has a remarkable history of canceling equipment competitions or even selections, then revising requirements and starting over.

India's tendency to move slowly and unsteadily in aircraft acquisitions means that Lockheed Martin can hardly wait for New Delhi to make its selection. Without another order, the company will deliver the last F-16, to Iraq, near year-end. Suppliers' production of long-lead F-16 parts has already stopped, but those companies remain ready to restart. But because of that halt, F-16 deliveries must cease for some period after this year, even if there is another order.

The nearest prospect is a contract from Bahrain, which has 20 F-16s, is upgrading them and wants as many as 19 more. At a production rate of one per month, that would give Lockheed Martin more than a year to find another customer.

The industrial rules for Indian defense import contracts are changing. Even after the government determined last decade that private companies could undertake some parts fabrication, the state organizations that had long controlled the industry continued to insist on heavy technology transfer, preeminence in high-level integration work and a leading role in manufacturing. But the government, fed up with decades of underperformance, is encouraging foreign suppliers to work with private companies only. Also, technology transfer has become less urgent to India, though no bidder for any project dares to neglect it entirely.

Lockheed Martin already has a private Indian manufacturing partner, the Tata conglomerate, which makes C-130 Hercules parts. Bidders for the air force and naval fighter programs are awaiting an imminent government statement on which local private companies will be preferred as military aircraft builders. Lockheed Martin intends to assemble F-16s in India if it wins the competition, regardless of whether Tata is on that list or not—and it is most likely to be there. Lockheed Martin's Fort Worth crew will continue to move over to the U.S.



government's big job, the F-35.

In offering long-term business to India, the company has the asset of more than 3,000 F-16s in service, many of which are candidates for structural life extension and systems upgrades. If it can involve local industry in those modernizations, then there should be manufacturing and development work for decades.

For UAC, the obvious MiG-35-maker would be HAL, the key state aircraft OEM. HAL makes UAC's Sukhoi Su-30MKI but will cease doing so in 2019. So shifting resources to building the MiG-35 could make sense.

Saab has no known Indian manufacturing partner. No doubt the announcement on officially sanctioned companies, which may be made within days or weeks, will help it make its choice. For technology transfer, Saab points to its commitment to building up the fighter-development competence of Brazil's industry as part of that country's order for 36 JAS 39E/Fs.

The Swedish company is suggesting deep Indian involvement in the development of the proposed carrier-based Gripen. It rejects criticism that it lacks experience in carrier aviation, noting it assigned the task of preparing a preliminary design of the seaborne version of the Gripen to British engineers who were familiar with Royal Navy operation of shipborne airplanes. Britain of the Tejas. In this and the air force program, Saab may have a considerable advantage over U.S. competitors in its flexibility for transferring knowhow. For example, it would expect to train an Indian partner to a high level of expertise in radars using active, electronically scanned arrays (AESA) and gallium-nitride technology, says Deputy CEO Micael Johansson. Saab is a leader in that field. The U.S. government does not allow its radar-makers to share AESA technology.

Boeing has a few hands to play in seeking the naval order, however. Its civil businesses could contribute to the industrial package accompanying an



has not employed arrested recovery for almost four decades, however.

Saab would most like to see the air force and navy linking their requirements so both could consider the advantages of ordering Gripens. There is no sign of such a linkage yet, however.

The Gripen would need stronger structure and landing gear for carrier landings but perhaps not as much modification as other land-based fighters would, says the company. It is already designed for steep landings, so it can use roads in hilly terrain as runways. Its flight-control system could reduce impact on meeting the deck.

India issued a request for proposals for naval fighters in January, after the navy rejected the carrier-based version INDIAN DEFENSE MINISTRY

offer of F/A-18E/F Super Hornets, the company says. Another possible part of the offer is the General Electric F414 EPE engine, which would provide 18% greater thrust than the F414 currently used by U.S. Navy and Royal Australian Air Force Super Hornets.

A key issue is likely to be satisfying requirements for local manufacturing. "We have lots of options, both commercial and defense," says Thomas Breckenridge, head of Boeing's Indian defense sales. His remarks imply that the company could increase its orders for commercial aircraft parts from the nation, a traditional offset arrangement, as part of an order for the Super Hornet. The government's Make in India policy, however, also prioritizes Indian manufacturing of some of the equipment bought for foreign supplier deals. Boeing has mentioned the possibility of a new manufacturing facility in India for the Super Hornet—though it would presumably not be intended to make all the aircraft parts.

A further possibility in Boeing's bid is Indian participation in improving the Super Hornet. The type is likely to serve into the 2040s.

Greater thrust could be particularly valuable, because the Indian navy's two aircraft carriers, one still under construction, are designed to launch aircraft with ski jumps, not catapults. With more thrust, an aircraft at a higher weight can achieve flying speed after accelerating along the deck and in the air for a few seconds after hurtling off the jump.

India requires deliveries of its new carrier fighters to begin three years after an order is signed and to be concluded in the following three years. With a warm Super Hornet production line running well below capacity, Boeing should be able to meet that easily subject to the complications of setting up manufacturing in India.

After a tortuous selection process, India has finally contracted Dassault Aviation to deliver 36 land-based Rafales for the air force. The navy appears to be taking seriously the possibility of operating Rafale Ms from its carriers. Chief of the Naval Staff Adm. Sunil Lanba visited the Dassault booth at Aero India on Feb. 15 for a lengthy discussion. Last year, a Dassault team briefed the service on the Rafale M as India was finalizing the design of its second indigenous aircraft carrier. One carrier, built and modernized in Russia, is in service. The ship under construction is the first Indian-built carrier.

A Dassault spokesperson confirms that the Rafale M will be offered. The company emphasizes the value of commonality between the Rafale M and the air force's forthcoming Rafale B and C. The Rafale M and Super Hornet are both designed for catapult launch, but their manufacturers say each could use a ski jump.

The Indian navy already has MiG-29Ks, so UAC sees an obvious opportunity in proposing more units of the same type, says the industry source. The Russian state company says the MiG-29K will have to be updated to suit the service, however.

# **Flanker Fixation**

# Proliferating variations on the big Sukhoi complicate Chinese force structure

#### Bradley Perrett Beijing

ow many Flanker versions does it take to defend China? Ten, it seems. No, make that 11. Best to keep counting.

Add to the Flankers the two versions of China's indigenous J-10 fighter, various marks of J-7s and J-8s that are lingering in service and the J-20 stealth fighter, likely to join the air force by the end of the decade. This is the variety of fighter types and versions, with a kaleidoscopic array of parts, that must be supported by a military that has no great reputation for logistics.

It is no wonder, then, that Avic's Shenyang Aircraft has been unable to persuade the air force to accept its stealthy new J-31 fighter, and that the earlier JF-17 of the group's Chengdu Aircraft has been limited to an export market.

The proliferation of types and versions means the air force and navy remain quite dissatisfied with the modernity of their fighters. The services should become increasingly comfortable, and production runs extended, as the latest models become more competitive with those of India, Japan, Taiwan and the U.S. There is little sign of that, however. China's Flanker force is becoming ever more fractured.

China's first unlicensed Flanker, the J-11B, has been followed by a strike version, the J-16, one unit of which was seen last year carrying a huge air-to-air missile evidently

designed to hit surveillance and tanker aircraft at extreme range. But one new standard of locally built Flanker is one too few, it seems, because photographs of one called the J-11D, an upgrade of the J-11B, have appeared as well; if it is confirmed as having entered service, it will be China's 11th Flanker variant, including trainers.

These improvements are obviously not improved enough, because China is importing 24 units of the Su-35, the most powerful Flanker so far. The number is too small to justify introducing a version for operational reasons alone. So it is fairly clear that the air force would like Shenyang Aircraft to tear down a few to see how unlicensed Flankers could be made better again.

The local engineers can get their wrenches out soon enough, if they have not already. Four Su-35s arrived in China last Dec. 25. The other 20 are due for delivery in 2017-18. Chinese propulsion specialists will be interested in examining the version's NPO Saturn AL-41F-1S (also known as 117S)

Chinese Fighter Force				
	Manufacturer	Туре	Number	
Air Force	Avic Chengdu	J-7 J-10	527 319	
	Avic Shenyang	J-8 J-11A J-11B, J-11BS J-11D J-16	144 95 110 1 4	
	Sukhoi	Su-27SK Su-27UBK Su-30MKK Su-35S	43 32 73 4	
	Avic Chengdu	J-10	23	
Navy	Avic Shenyang	J-8 J-15	24 15	
	Sukhoi	Su-30MK2	24	
	o: Aviation Wook Intolli	Total	1,438	

Source: Aviation Week Intelligence Network fleet database

engine. This has greater thrust than the AL-31F of earlier Flankers and features thrust-vector control. Importantly for future Chinese fighter programs, this engine can drive the Su-35 at supersonic speeds without afterburning.

Given the arrival of new technology in the Su-35, there is every reason to wonder whether Shenyang Aircraft's Flanker specialists will soon wave another proposed local version under the air force's nose.

A Russian industry source plays down China's opportunity to acquire

know-how from the Su-35. First, he points out, only so much can be learned from examining an aircraft's pieces. Second, Flanker builder United Aircraft Corp. is moving on by developing a far more advanced type, the T-50. The same source, while disclaiming specific knowledge, expects China to order more Su-35s.

The military trading relationship between China and Russia is usually seen as one-sided, with Moscow needing Beijing's money. But U.S. defense analysts Phillip Saunders and Joshua Wiseman have pointed out that dependency goes both ways: China can turn only to Russia for anything it cannot make locally. Western sources are closed. That may explain China's difficulty in sealing the Su-35 contract, which was under negotiation for four years before agreement

in 2015—when Russia's economy was weak and Sukhoi was anxious for an order.

So far the Chinese navy has one shore-based Flanker version and one for carrier operations. The latter, the J-15, is copied from the Russian Su-33 and is designed for ski-jump takeoffs. China is obviously planning to build carriers fitted with catapults. To cope with the structural stress of catapult launch, the navy will need a new model fighter—or a new Flanker version.

Compared with its profligate Flanker development, China has exercised much tighter configuration control with its currentproduction indigenous fighter, the J-10, which has so far appeared in only two main versions. Entry into service of the J-20 will add another type to the inventory, but with the justification of special capabilities. Among the J-20's possible applications is piercing an enemy fighter

barrier to attack support aircraft.

That leaves open the question of what will succeed the J-10. The best answer, so far, is "something better than the J-31." Although that Shenyang Aircraft type is often listed alongside the J-20 as China's other low-observable fighter, it so far seems to be no more than a technology demonstrator. Despite the J-31's stealth shaping and internal weapons carriage, the air force has not been persuaded that the J-31 is superior enough to the J-10 to justify halting production of the latter and introducing yet another new type. ©

# AVIATION WEEK MROO AMERICAS

## April 25–27, 2017 | Orlando, FL | Orange County Convention Center





# What you need to know about MRO Americas!

- **EXHIBITION** Explore new technology, tools and services.
- **NETWORK** Access thousands of airlines, MROs, OEMs, suppliers and service providers.
- NEW OPPORTUNITIES Featuring dedicated IT, GSE and Military programming! Plus the MRO University and Aerospace Maintenance Competition!
- **CONFERENCE** Analyze status and trends in the MRO market. Drill down into business development, engineering, propulsion, IT, innovation, supply-chain/logistics, leasing and more!
- HOTEL AND THEME PARK DISCOUNTS Get the best rates at some of the hottest properties in Orlando. Save big at local attractions including Disney and Universal Studios!
- GOLF TOURNAMENT Join your fellow attendees on the course. MRO Americas tees off at Shingle Creek Golf Course.

## REGISTER TODAY FOR THE CONFERENCE AND FREE EXHIBITION ACCESS.

mroamericas.aviationweek.com

# **Thunder Road**

## Advanced JF-17 versions coming, 10 years after service entry

#### Alan Warnes London

ties being introduced at a rapid pace, 2017 looks set to be an important year for the JF-17 Thunder developed by China and Pakistan.

The first flight of a two-seat version—JF-17B—is planned for the first quarter, Pakistan will stand up its fifth squadron flying the aircraft, and contracts are due to be signed for the most advanced variant, the Block 3, complete with active, electronically scanned array (AESA) radar.

The new fighter is critical to the Pakistani air force's growth plan. Besides introducing new capabilities, it helps avoid Western sanctions that have previously blighted its operations. The development of a two-seat version is seen as key to adding capabilities and generating export orders. Assembly of the first twin-stick aircraft is underway at the Pakistan Aeronautical Complex (PAC) in Kamra. Three are being built, one for China's Avic and two for Pakistan's air force. Having a two-seater in the testing and development program will speed up the integration of weaponry, according to Chinese partner Catic. The first JF-17B is expected in Pakistan by mid-2017.

"Pakistan's air force has never needed dual seaters to train its fighter pilots. We took delivery of the Shenyang F6, Chengdu F-7P/PG, Hongdu A-5C and the JF-17 without a trainer version," says Air Marshal Arshad Malik, the chairman of PAC. "But we appreciate the Thunder's technologies will be new to many of our markets [in Africa, the Middle East and Asia] so we opted to develop a dual-seater with our Chinese friends," he adds.

With contracts for 50 Block 1 and 50 Block 2s signed and deliveries of all but the last 14 Block 2s, attention is now switching to a contract for 50 Block 3 models. However, it is looking increasingly as if production of these aircraft will not start until 2019, and as a result PAC will manufacture 12 additional Block 2s in 2018, to ensure production does not halt.

A decision on a new AESA radar for the Block 3s will be made this May. There are several contenders, including at least two Chinese options. One is the upgraded China Electronics Technology Group Corp. KLJ-7A, while Leonardo (formerly Selex ES) is also offering a system.

Another improvement is an aerial refueling capability. Trials and qualifications of a new production aircraft built with a Chinese inflight refueling probe are also reportedly underway.

Block 3 enhancements will also include new avionics, better electronic warfare systems, increased payload and more sophisticated weaponry. PAC officials describe it as the ultimate JF-17—and with an AESA radar, it will have the capability to employ longer-range weapons and track multiple aircraft. If the requirement is there, Block 1/2s will be upgraded to the Block 3 standard later.

The Russian-made Klimov RD-93 engine, which has flown over 30,000 hr. with Pakistani air force JF-17s, will likely to be replaced by a Chinese option. But this will take time and will come as an upgrade.

Since the first two JF-17s made their public debuts with the air force in March 2007, production has switched from Chengdu Aircraft Industry Corp., where the first 10 aircraft were built, to PAC Kamra. The first fighters left the production line in November 2009, and another 76 have followed.

Setting up assembly facilities has not been easy for a country with no previous experience building fighters. "Creating the production line and building up a skilled labor force is a massive task, but we have done it and are now building 58% of the JF-17 at PAC Kamra," says Malik.

PAC is currently producing 16 aircraft a year for the air force; the 16th fighter aircraft for the service was handed over on Dec. 31. A similar number will be delivered this year to cover the last batch of Block 2 jets. "We can increase our output even further to cope with future exports," Malik adds. Nigeria has already confirmed an order for three JF-17s, but no further details are known.

Pakistan's air arm is operating the JF-17 with four squadrons at four bases, with a fifth due to form shortly. Its aircraft have been qualified for the anti-shipping role, equipped with the C-802AK missile and air defense duties with the SD-10A beyond-visual-range air-to-air missile (AAM) and the PL-5E short-range AAM.

Several air-to-surface weapons have also been integrated, including the CM-400 stand-off supersonic missile and the CM-102 lightweight anti-radiation missile. Work with the 500-lb. GB-1 laser guided bomb and the YINGS III targeting pod, on display at the Zhuhai Air Show last November, is underway. Pakistan's air force is exploring further options as it looks to continuously boost its operational readiness.

The PAC/Chengdu JF-17 Thunder has been in service with Pakistan's air force since March 2007 and now is operated by four squadrons, with a fifth expected soon.

150

# **Not Quite Alone**

## South Korea plans minimal outside help for its fighter radar program

#### Kim Minseok Seoul and Bradley Perrett Beijing

f Hanwha stumbles in the challenging task of developing an advanced radar for the KF-X fighter, Elta will probably be there to catch it. In fact, the Israel Aerospace Industries electronics unit likely will be contracted soon to validate the South Korean company's radar program.

Although the initial version of the KF-X is not intended to be highly stealthy, prime contractor Korea Aerospace Industries (KAI) is studying techniques for controlling radar reflections. Meanwhile, wind-tunnel testing of a slightly modified airframe shape for the twin-engine aircraft has begun. The KF-X grew about 2% before it was launched in December 2015.

The program is working toward a preliminary design review in June 2018 and a critical design review 15 months later. That will leave about two years for detail design. The prototype should be rolled out in 2021 and fly in 2022. The South Korean air force says the target for first delivery, previously reported as 2026, is actually 2024, suggesting a tight schedule for flight testing. Moreover, final operational capability of the fighter, to be powered by the General Electric F414 engine, is supposed to be achieved in 2026. Indonesia is a junior partner, reportedly planning to buy 50 KF-Xs; South Korea wants 120.

One major challenge is in creating a South Korean radar with an active, electronically scanned array (AESA), as Hanwha was chosen in April 2016 to do. Government research, begun in 2006, has been limited to work on the ground. Hanwha's electronics unit (formerly Hanwha Thales) has never built a complete fighter radar, not even under license-though it did make the transmitter for the Elta EL/M-2032 when rival LIG Nex1 manufactured that sensor for the KAI FA-50 light strike aircraft.

Aware that the country would need help, foreign radar-makers promoted their technologies. In 2015, it seemed that one would be chosen for deep involvement in the radar effort. But a government source says Elta, chosen as the partner, will only help verify characteristics of a sensor of South Korean design.

The defense ministry's Agency for Defense Development (ADD) has prepared a preliminary design of the hardware, setting the number of transmitter-receiver modules, power output and cooling capacity. Hanwha will fully develop it. Considering the lack of domestic experience, and the potential for radar development to hold up the entire KF-X effort, there is clearly a chance that ADD and Hanwha will at some point have to ask

KAI is wind-tunnel testing the latest KF-X design, C105.

Elta for assistance beyond validation.

Without confirming the choice of Elta, a spokesperson for the ministry's purchasing office, the Defense Acquisition Program Administration, says negotiations on the contract are progressing. The current issue is satisfying Elta's demand for protecting its technology, says the government source.

Other contenders were Saab and Leonardo's radar unit, then called Selex. U.S. radar-makers did not compete, because Washington refused to allow the transfer of AESA integration technology for KF-X, even though Lockheed Martin is supporting the fighter program technically.

The South Koreans have been working in the background. ADD and LIG Nex1 built and ground-tested an AESA

research radar in 2011-13; it was not intended for installation in an aircraft. In a follow-up program covering 2014-19, ADD and Hanwha have made and are testing a second ground research AESA radar. A third research effort, in 2016-18, covers building and testing a radar for installation in an aircraft. But it will not have the design used for the sensor in the KF-X, which should go into volume production in 2020. Flightcontrol technology will be tested in an FA-50.

KAI last year ordered research into stealth to be conducted in 2016-17. The exact technology it is working on is unknown, but the company says it is looking at canopy coatings, frequencyselective radomes and how to repair radar-absorbent materials. It is also working on stores separation from a weapons bay, a particularly tricky problem at supersonic speed.

This work is presumably aimed at

 $_{\overline{>}}$  the goal, set in 2009, of achieving stealth characteristics like those of the Eurofighter Typhoon and Boeing F/A-18E/F Super Hornet. The KF-X still has the shape necessary for higher stealth, inherited from pre-2009 plans, but will not have all the other features needed to achieve it. ADD proposed in 2013 that a second ver-

sion be fully stealthy, but that has not been funded.

Slight enlargement of the KF-X probably occurred late in preliminary development. The design chosen when Lockheed Martin became the designated partner, C103, has been replaced by C105, first shown in December 2015. Its wingspan grew to 11 m (36 ft.) from 10.7 m, and length to 16 m from 15.6 m. Empty weight is now 11.1 metric tons, up from 10.9, while gross weight has risen to 24.5 metric tons from 24.

Examination of C103 and C105 drawings shows that this was essentially a wing enlargement, with the center fuselage necessarily lengthened to suit. The tail fins are also a little larger. Fuselage height and width did not increase noticeably, if at all.



# TWENTIES To Watch

**20 TWENTIES** 

**Carole Rickard Hedden Washington** 

**Every so often, someone comes along who is going to change the world.** What remains to be seen is where and when that someone will have the opportunity. With that in mind, Aviation Week and the American Institute of Aeronautics and Astronautics (AIAA) collaborated with universities around the world to identify 20 undergraduate or master's degree students who already are forging ahead on that mission. And when the AIAA panel finished the evaluations, an important finding emerged—more than 70 students clustered at the top of the ranking, their scores differing by just hundredths of a point.

With nominations from engineering programs at 37 different universities, the panel of judges looked for what sets the mark in a student they would want to hire: a fire for digging deeper and working harder to discover something new, and an interest and concern about the world beyond their studies.

It seemed only fair, then, to turn the tables and ask the students for their measure of the aerospace and defense industry. Their responses were enlightening.

#### Given all the scientific/technological/engineering challenges that face us in this world today—what do you consider to be the grandest challenge of them all?

Overwhelmingly, the 20 Twenties pointed to the need to protect the climate and find alternatives that yield clean, sustainable energy. Other areas winning their attention were deep-space exploration and interplanetary travel as well as artificial intelligence and the understanding/security of cyberspace.

As Geoffrey Andrews notes, "Our history as a species has always been one of exploration and of survival, so our future will be bleak indeed if we remain confined to our home planet."

John Deaton of the U.S. Air Force Academy says, "I would love to see things like flying cars and regular trips to Mars," but he notes: "None of that would matter if we end up depleting the Earth's resources and are forced to abandon many of our post-industrial achievements.... [We need] sustainable solutions to enjoy prosperity and technical advancements without fear of resource depletion."

## What grade would you give to the aerospace and defense industry in attracting a future generation?

Most of this year's 20 Twenties gave industry a B, though there were a few Cs as well. On the positive side, the students gave high marks for the "cool factor" of what the industry does through highly visible, important programs. "My generation is electrified by the rise of commercial space," says Keenan Albee.

Students also pointed to effective outreach and science, technology, engineering and mathematics (STEM) programs. And they noted that the industry places The AIAA leaders who scored this year's nominations:

**Cornelia Altenbuchner** *Robotics Modeling Technologist NASA Jet Propulsion Laboratory* 

**Thomas Becher** *Technical Director Mitre Corp.* 

#### Daniel T. Jensen

Head of Engineering Services, Propulsion and Power Systems Rolls-Royce Ltd.

#### Crystal L. Pailisao

Assistant to the Chief Scientist U.S. Air Force Research Laboratory/ RW Munitions Directorate

#### George Zhu

Professor of Aerospace and Aeronautics York University, Canada

a high value on continuing education, which is appealing to most of them.

But these are ways in which they say the industry could do better: improve diversity, compete with the booming tech companies in the area of innovation, and sustain outreach to students before and during college.

■ Eighty percent said diverse work experiences and internships are the most important factor.

 Just over half cited the influence of parents/family members and teachers.
 Forty percent said mentors (whether personal, academic or from industry) were most important.

Also important were hands-on classes, professional/networking societies and community/volunteer work.

A third of the students reflected on their own contribution to how that career works out. As Julia Di explains, "I always viewed art as more of my purview than engineering. Yet I'm studying engineering now. I never expect success, which is an attitude that keeps me humble and hardworking, and pleasantly surprised when I do succeed."



**Geoffrey Andrews** earned his bachelor's degree in mechanical engineering at Lehigh University and is now a graduate student at Purdue University in astronautical engineering. He was a co-op student employee at NASA Glenn Research Center, a research assistant in the Lehigh Aerospace Systems Lab and an undergraduate research fellow at the Lehigh Bio-Nanomechanics Lab, where he worked on a method to fabricate microfluidic devices using direct-light processing lithography on a microscopic scale.

Andrews is the chief maintenance officer for Purdue Pilots Inc., was founder and first president of Lehigh's chapter of AIAA and a member of the university's Philharmonic Orchestra, Wind Ensemble and Marching 97.

**Jakob Bludau** will finish his master's degree in mechanical engineering this year at the Technical University of Munich. He has served as a research assistant at the university's Internal Combustion Institute and the Aerodynamics and Fluid Mechanics Institute. He also has been an intern at Eurocopter Deutschland, where he worked in destructive and nondestructive testing. Notably, Bludau holds a European patent through Eurocopter for an ultrasonic testing protocol for mechanical components.



In addition to his technical studies. Bludau serves on the university's student governance body and as the head of its university politics division, which oversees the development and certification of bachelor's and master's degree programs for mechanical engineering. He volunteered for civil service for one year in Ecuador, where he taught English, protection of the environment and computer training.



Keenan E.S. Albee will graduate from Columbia University this May with a degree in mechanical engineering and minors in computer science and history. He has completed internships at Boeing and Johns Hopkins University, and he held a research associate role at NASA Armstrong Flight Research Center. In addition to research in kinematics simulation of a robotic neck brace. Keenan has developed carbon-fiber and aluminum structures. He is co-president of the Columbia Space Initiative, served on the Executive Council of the University's Maker Space student workshop, and was the aerodynamics system lead for Columbia's Formula racecar in SAE's competition. On top of these achievements, Albee is a hacker-legitimately. He was the Hack MIT Best Synaptics winner in 2015, won the Craziest Hack prize at the YHack, and was the Yodel Hardware Hack Winner at HackPrinceton.

**Julia Crowley Farenga** is this year's 20 Twenties top student. She is working on her master's degree at Purdue University and earned her bachelor's degree in aerospace engineering at the Massachusetts Institute of Technology in 2016. Julia has worked with two of the companies pushing the envelope in today's new space race—both SpaceX and Blue Origin. Last summer, before beginning her graduate work at Purdue, CrowleyFarenga joined SpaceX as an employee working on advanced Mars technology concepts.

#### **20 TWENTIES**



#### John L. Deaton

is ranked No. 1 in his class at the U.S. Air Force Academy based on a combination of academic, military and athletic performance. As a first-class cadet, he was chosen for the Wing Outstanding Four Degree, which designates the best all-round cadet. An aeronautical engineering major, his minor is in Chinese. Deaton is a flight

commander, responsible for the development and performance of 25 underclassmen, and was Cadet Director of Operations for the academy's 94th Flying Training Sqdn. He interned at NASA Johnson Space Center on data reduction methods and optimization for a flush air data system for the SpaceX Dragon Crew Capsule.

In addition to the rigors of the academy, Deaton traveled to the Dominican Republic to work with Rays of Hope International, providing manual labor in support of local projects to aid an impoverished community.



Jennifer Domanowski will graduate from Boise State University this May with a degree in materials science and engineering and a certificate in Korean. She was a Pathways intern at NASA Goddard Space Flight and Glenn and Marshall Research Centers. She is president of the Tau Beta Engineering honor society, a peer ambassador for the university's College of Engineering and a member of AIAA.

Domanowski managed an engineering lab at Boise State and developed new experiments for lab modules for the university's undergraduate courses. She is a first-generation college student, and of particular note is her passion for education, sharing with her peers and future STEM students.



**Karl Domjahn** is earning his master's degree in mechanical and aerospace engineering at the University of Queensland in Brisbane, Australia. In addition to his coursework at Queensland, Karl worked at the Mobile Rocket Base with German aerospace center DLR on research in sounding rockets, including the design and building of mechanical mountings to secure measurement hardware within a flight module. Domjahn is the national secretary of the Australian Youth Aerospace Association.

**Julia Di** is a junior at Columbia University, majoring in electrical engineering. She has been a research assistant at NASA Marshall Space Flight Center and a laboratory associate at Columbia's Carleton Lab. Di founded Columbia's Space Initiative and was designated a super-user at the university's Maker Space. She was also chosen for the Res Inc. program at Columbia—only 30 students from across the university are chosen for this student residential entrepreneurship incubator.

is a junior majoring in aerospace engineering and was a founder of the Women in Aeronautics and Astronautics organization at the University of Michigan. She is a copy editor at the Michigan Daily, the university's student newspaper, and served as a teacher and tutor with the EKARI Foundation, teaching English in rural Africa to help students prepare for their national college entrance exams.

Brian Free is earning a master's degree in flight dynamics and control at the University of Maryland, focusing on bio-inspired robotics at the vestibular system level. He graduated at the top of his undergraduate aerospace class at Maryland in 2015 and is a National Science Foundation Graduate Research Fellow. In addition to his aerospace studies, Free is treasurer of the Terps Roots and Shoots, a student organization that coordinates community, environmental and animal projects.

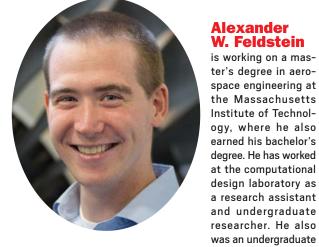


Alexander

W. Feldstein

Kelly Henckel is a junior at the University of Michigan, majoring in computer science engineering with a focus on aerospace engineering. She interned at Northrop Grumman, where she was co-lead researcher on camera systems research and embedded system controls. For her research project at Michigan, she was the lead software and electrical engineer on development of a hovercraft. Beyond her engineering pursuits, Henckel is a member of the RC Players Theater, Michigan Biological Software Team and the Michigan Rifle Team.





research assistant at the Imperial College of London. Feldstein interned with Boeing's Research and Technology group and for the Cessna Aircraft Co., now Textron Aviation. He also was selected for MIT's Mechanical Engineering de Florez Award for individual undergraduate research projects and was recognized with the AeroAstro Teaching Assistantship Award. A coxswain for MIT's heavyweight crew team, Feldstein is a member of the MIT Student Athletic Advisory Committee, on which he coordinated community service, athletics promotion and athlete well-being for all of MIT's varsity athletes.

AviationWeek.com/awst

#### **20 TWENTIES**

**Rubbel Kumar** is a master's degree student in aerodynamics and propulsion at the University of Maryland, where he also earned his undergraduate degree in aerospace engineering. Concurrent with being a graduate student, Kumar is on staff at Johns Hopkins University Applied Physics Laboratory (APL), where he has worked since August 2014. With fluency in Hindi, Punjabi and Spanish, Kumar participated in the Leadership Essentials program at Loyola University and has amassed more than 260 volunteer hours working with organizations ranging from the APL Center for Talented Youth, Maryland Mathematics Engineering Science Achievement and the University of Maryland's Women in Aeronautics and Astronautics Day.





**Matthew R. Hurst** is a senior at the University of Colorado at Boulder, majoring in aerospace engineering. His technical research has included the application of multiple-fidelity modeling in airfoil design and analysis. He served as project manager of a Capstone project to design, build and test a proof-of-concept light-detection and scanning system for extraterrestrial spacecraft landing. Hurst was a member of a three-person team competing in the International Mathematical Contest in Modeling—and that team was chosen as one of six outstanding teams among 4,094 teams. He interned with Lockheed Martin, where he was recognized as an outstanding intern, and he also interned with the National Oceanic and Atmospheric Administration's Global Systems Division. Hurst traveled to Puerto Penasco, Mexico, to build housing for homeless families and helped to build and wire a home for a local family in Guatemala. **Braven G. Leung** is a graduate student at the Georgia Institute of Technology after completing his undergraduate degree in aerospace engineering at the University of Illinois Urbana-Champaign. His graduate research is focused on the FAA's Continuous Lower Emissions, Energy and Noise Program. Leung worked as a consultant intern for Booz Allen Hamilton and as a flight systems avionics intern for NASA's Jet Propulsion Laboratory. He also interned as a systems engineer for Raytheon Space and Airborne Systems. He has a National Defense Science Engineering Graduate Fellowship, received the Dale Margerum Memorial Award for outstanding leadership at Illinois and was selected for the NASA SpaceOps Student Award for technical and scientific excellence.



**Wanyi Ng** graduated from Duke University with a B.S. degree in mechanical engineering and is currently in the master's degree aerospace program at University of Maryland. She was a Pathways Intern at NASA Goddard Space Flight Center. As an undergraduate, Ng was the vice president of finance for the Duke Engineers for International Development and worked with Brazilian undergraduate engineering students to implement a rainwater catchment system. She also worked on the design of a gray-water management and water distribution system in Honduras. She is active in the American Institute of Aeronautics and Astronautics, American Helicopter Society, Society of Women Engineers and American Society of Mechanical Engineers. Beyond her studies and volunteerism, Ng is a part-time company artist with the DC Contemporary Dance Theater in Washington.





**Kristen Railey** is a graduate student in a joint program between the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institute. She earned her B.S. degree in mechanical engineering at MIT in 2013. Railey is a tactical navigation fellow at Draper Labs and was an assistant with Lincoln Lab's Advanced Undersea Systems and Technology group. She founded an outreach program for high school girls, "Girls Who Build," to increase the number of women in engineering. She also published online curricula for Make Your Own Wearables and Girls Who Build Cameras workshops at MIT.

#### Emily M. Zimovan will

complete her master's degree in aeronautical and astronautical engineering at Purdue University in May. She earned her B.S. at Purdue, accumulating a perfect grade point average. Zimovan interned at NASA Johnson Space Center, where she worked in guidance, navigation and control autonomous flight systems and optical navigation. She was an aeronautics scholar at NASA Langley Research Center, working on experimental hypersonic aero-thermodynamics, and also worked as an intern on the James Webb Space Telescope at NASA Goddard Space Flight Center. Zimovan received the Purdue Industrial Roundtable Scholarship and the Space Shuttle Memorial Fund Scholarship, among a number of others.

**Rose Weinstein** will graduate in May with a bachelor's degree in aerospace engineering from the University of Maryland. In addition to her research at the university, she was a summer intern at NAS Patuxent River with Northrop Grumman Aerospace Systems and was a flight test engineer at Baltimore Washington International Airport. A vice president of the Women in Aeronautics and Astronautics organization at the University of Maryland, Weinstein is an ambassador for the James Clark School of Engineering. She is a student pilot and volunteers as a mentor/tutor with the Volunteer Peer-Assisted Learning Program.





PURDU

**Christine Reilly** is a junior at the University of Colorado majoring in aerospace engineering and minoring in astronomy and participating in the Discovery Learning Apprenticeship Program. She interned with The Aerospace Corp. and was a systems engineer for the Colorado Space Grant Consortium. She was project manager on the gateway to the space balloon satellite project at the university and was named an outstanding winner of the International Mathematical Contest in Modeling, placing among the top five of 2,280 international undergraduate teams in 2015. A National Merit finalist, she was awarded the Virgin Galactic Unite Bytheway Scholarship.

## **Voice Control** Reconfigurable ATC communications

## system enters testing

#### John Croft Melbourne, Florida

hen heavy rains in October 2015 flooded the radar room of the Austin-Bergstrom International Airport's air traffic control tower and terminal radar approach control center, knocking out crucial voice and radar feeds, it took FAA technicians several days to transfer those feeds to the backup location. In the interim, even a satellite communications link failed to provide relief due to severe weather and heavy rainfall.

A year earlier, a disturbed worker sabotaged and burned sections of the Chicago Air Route Traffic Control Center (ARTCC), cutting the connection to the FAA's telecom-

munications infrastructure (FTI) network. FTI in part carries communications between controllers and aircraft. The resulting "ATC-Zero" event left the facility unable to control traffic for two weeks, reportedly costing airlines more than \$350 million in delayed and canceled flights.

What Austin and Chicago needed to maintain critical aircraft-toground and controller-to-controller voice calls was a network that could be reconfigured on the fly, allowing for what the FAA calls "dynamic resectorization and offloading" of airspace. The FAA's solution to the problem—the National Airspace System (NAS) Voice System—will allow controllers at any tower, terAll and a local data an

A fire in the Chicago center in 2014 knocked out voice and radar feeds, creating a "donut hole" where aircraft could not fly.

minal radar approach control center (Tracon) or ARTCC to reroute voice and ground calls, ensuring communication continuity with pilots.

NAS Voice System (NVS) prime contractor Harris Corp. plans to begin acceptance testing of the hardware and software this summer, the first in a long line of certification efforts that will culminate in a fully operational NVS around 2025. Harris won the 15-year, \$291 million contract in August 2012.

"With NVS if there is an anomaly at an ARTCC such as Chicago, we can reallocate frequencies so that you don't have to stop planes from going into that center, creating a donut hole in the airspace," says Leigh Lynch, NVS program manager for Harris Mission Networks. "With NVS, the airspace can be managed by controllers at another facility. That cannot be done today."

That it cannot be done yet is a sore point with the Transportation Department's Office of Inspector General (OIG), which in a new audit report says the agency has a significant amount of work remaining to "mitigate the impact of air traffic control [ATC] disruptions." The FAA in the aftermath of the Chicago fire updated its contingency plans, setting a goal to achieve 90% capacity within 24 hr. at the top 30 airports with the most passenger traffic, and 90% capacity at facilities that manage air traffic at high altitude in the vicinity of airports within 96 hr.

The OIG says that while the FAA has "taken steps to improve the effectiveness of its operational contingency plans," procedures for transferring airspace and ATC responsibilities to other facilities—known as airspace divestment—remain incomplete, and controllers have not received the necessary training to handle such emergencies. However, even with upgraded training the legacy point-to-point voice-switching equipment, which allows controllers to speak only to the aircraft within range of a nearby radio site, can do just so much.

The FAA says NVS will not be "limited by geography" and will give the agency the "flexibility to shift workload among multiple [ATC] facilities, if needed."

NVS is one of four NextGen technologies the OIG says will help the FAA "improve the continuity" of air traffic operations during emergencies, but with a 2025 completion date, it will perhaps be the last to be implemented.

Despite the long horizon, the tempo of test activity at Harris's Melbourne, Florida, facilities is high. In the factory acceptance test equipment room, the company's engineers are

> vetting NVS equipment on 255 simulated air traffic controller workstations, preparing for FAA acceptance tests that will start this summer. NVS connects the FAA radios to the FTI, which Harris operates for the FAA under a 15-year contract that was recently extended five years, until 2022. The total value of the 20year contract will be approximately \$5 billion.

> NVS will replace a variety of legacy voice switches with voice over internet protocol (VoIP) technology to share resources across FAA facilities, while also giving the agency an enterprise manager dashboard to monitor the status of all towers, Tracons and ARTCCs, facilities that today are "all islands," says Lynch.

Harris has also sold its NVS design to UK air navigation services provider NATS, as well as to the those of Turkey and Taiwan. Lynch says there are approximately 1 million lines of code in the NVS software.

After finishing the factory acceptance tests of the production NVS equipment in Melbourne, the FAA will complete system tests at the agency's William J. Hughes Technical Center near Atlantic City, New Jersey, and the Mike Monroney Aeronautical Center in Oklahoma City. The first field tests, called key site testing, will take place in Seattle in 2019 with NVS installed in a tower, Tracon and ARTCC, to be followed by a nationwide rollout of the system in 2019-25.

The extensive testing time is needed in part to verify that NVS will connect to 126 different types of ground-to-ground voice connections, some of which are archaic by today's standards. These include rotary dial phones and phones with touch pads that are still in place at certain remote locations, says Paul Klett, FTI system engineer for Harris Mission Networks.

Once NVS is fielded, however, ATC-Zero events involving voice communications should by all indications be a thing of the past. "Had NVS been in place at Chicago, it would have been a very different outcome," says Carl D'Alessandro, president of Harris Critical Networks.

# Strategic Planning Simplified



## Data and Insight to Maximize Revenue

Aviation Week Network's 2017 Military Fleet & MRO Forecast is the unsurpassed resource for providing insight into the future of the military aviation market, allowing users to compose plans, devise strategies, assess markets and maximize revenue generation. The forecast covers all Westerndesigned, piloted military aircraft—over 40,00 aircraft of over 1,200 types—with projections for every type and operator for each of the next ten years.

## Gain a competitive advantage. The easy to use interface simplifies:

- Discovering future in-service fleets by aircraft family or variant; manufacturer, mission & submission category, aircraft weight class, any combination of these and more
- Obtaining details on deliveries and retirements, broken down by type and certainty
- Understanding MRO requirements projections for these fleets, including utilization; field maintenance, labor & materials; and depot maintenance for airframes, engines and 12 categories of components

## See for yourself. Contact us today:

Aviationweek.com/2017forecast | 1.866.857.0148 or +1.847.763.9147







# Hybridizing Helicopters

Turbine-electric power could reduce engine size and fuel burn in helicopters, says Safran

#### **Tony Osborne London**

Safran has begun studies into the use of hybrid power on helicopters as a way to cut fuel consumption. The French company believes that the right-sizing of engines through the use of a turbine-electric hybrid power system could cut fuel consumption by 10-15%.

"The main issue in twin-turbine helicopters is that the engine is sized for one-engine inoperative [OEI] flight," says Cyrille Poetsch, executive vice president for programs at Safran Helicopter Engines (formerly Turbomeca). Engine failures on modern helicopters are infrequent, with the result that engines are not fully optimized for the size of the aircraft.

Safran is looking to see whether the power that would be needed in the event of an engine failure can be provided to the helicopter's gearbox in a different way.

"Engines are overpowered by a ratio of 20% to meet OEI operations," says Poetsch. This could mean that an aircraft such as Airbus Helicopters' Super Puma, currently powered by Safran's 1,877-shp Makila 1A1 turboshafts, could perhaps be powered by the lighter 1,400-shp Ardiden 3, with the hybrid system providing the additional power when needed. Poetsch says the studies are being conducted with several other Safran companies, including the OEM's electronics and defense business, formerly known as Sagem. Such a system would likely require advanced batteries and electric motors to provide the power to the gearbox. "We just need to convince the pilots that it is safe," he says.

A small number of electric-powered helicopters have flown, but batteries lack the energy capacity required for sustained flight. Airbus Helicopters in 2011 tested a single-turbine fitted with an electric motor to power the rotor during autorotation after engine failure, but there are doubts that the added safety margin justifies the extra weight.

Electric-powered tail rotors are also being tested, to minimize the power offtake from the main engines, but again there are concerns about complexity and weight. A hybrid turbine-electric propulsion system, however, would allow the entire powertrain to be reoptimized to minimize weight and fuel burn.

The hybrid work follows Safran's studies into a sleeping engine system where helicopters would be able to shut down one turboshaft during cruise to save fuel and then spool it up again rapidly when the aircraft began entering the hover or another critical moment of

#### Hybridization could allow a large helicopter such as this Super Puma, pictured with its Safran Makila engine, to be powered by smaller turboshafts.

flight. A similar system can be found on cars, which can cut their engines while stopped in traffic; the engine restarts when the driver touches the gas pedal. "It is a very promising technology," he says.

"Our target is to team with a manufacturer to demonstrate [the hybrid system] on a helicopter and work with the regulatory authorities such as EASA [European Aviation Safety Agency] to see the constraints. I think we could see a flight demonstration in the next two years," Poetsch says.

The development comes at a challenging time for the helicopter industry, which is suffering from a lack of orders in part due to the low price of oil and gas affecting offshore extraction and sales of medium and large helicopters. Safran had been considering research and development on a new generation of turbine engines for light helicopters, but Poetsch says the market is not ready.

"This is a cost-driven market. Operators want proven, robust and low-cost engines," he says. Instead, Safran's focus is on reducing production costs with the use of additive manufacturing, as well as reducing direct operating costs and increasing reliability and time between overhauls.

Work is continuing on the 2,000-3,200-shp Tech3000 turboshaft, a derivative of the RTM322 that Safran hopes will power the next generation of 8-15-metric-ton helicopters. The company has already tested a new compressor and low-pressure turbine, and later this year it will run a new hot section and high-pressure blades. The engine will likely power Airbus's X6 replacement for the Super Puma family of helicopters, but Poetsch says there are other prospects.

In December, the company started up its first entirely automated production line for turbine-blade manufacturing as part of its Factory of the Future project (*AW&ST* Jan. 23-Feb. 5, p. 35), while a program called CAP2020 is focused on rejuvenating the company's support and services at its Tarnos facility in France. ♥

-With Graham Warwick in Washington

## **CLASSIFIED ADVERTISING**

#### **To Place Your Classified Ad Contact:**

Miguel Ornelas; Tel: 661-480-7000 · miguel.ornelas@penton.com

## ABARIS TRAINING www.abaris.com ADVANCED COMPOSITE

**TRAINING & SERVICES** 

ADVANCED COMPOSITE TRAINING

#### EQUIPMENT



- Ultrasonic immersion tanks and gantries
- New construction and system upgrades
  Conventional and phased array ultrasonic inspection
- Conventional and phased array ditrasonic inspection
   C-Scan and full waveform collection capable
- 508-393-0155 www.matec.com

#### **EQUIPMENT**

Eujian Longxi Bearing Certified SAE AS81820 Type A Spherical Bearings with DuPont<sup>™</sup> Vespel® Technology

www.ls-us.com

#### RECRUITMENT

#### Innovative Solutions and Support Exton, PA IMMEDIATE OPENINGS!

- Mechanical Design Engineer
- Avionics Sales Professional
- Software Engineering Manager
- FAA Sr. Certification Office Manager (Burlington, MA Office)
- Repair Station Manager
- Business Development Administrator
- PT Customer Service Administrator

#### To Apply:

humanresources@innovative-ss.com IS&S is an Equal Employment Opportunity and VEVRAA employer and more!



From treading water to solving global problems.

Where are you headed? If you're ready to get what you want out of your job — out of your life — the smarter route is at UPS. Today, you might be stuck in the job you need, but at UPS, you can get the future you want. As a growing, dynamic Fortune 50 organization, we have the kind of opportunities that will help you go as far as your ambition will take you. You're ready for bigger things, and we'll get you moving in the right direction.

#### **AVIATION CAREERS AT UPS!**

Full time careers include: Multi-discipline Engineers, Aircraft Maintenance Management Trainees, Aircraft & Simulator Technicians, Dispatchers, Supervisors and First Officers!

Text UPSJOBS to 33588 or visit jobs-ups.com/print

Get there

\*By participating, you consent to receive text messages sent by an automatic telephone dialing system. Consent to these terms is not condition of purchase. Message and data rates may apply. T&C Privacy Policy: www.SMS-terms.com



UPS is an equal opportunity employer - race/color/religion/sex/national origin/veteran/disability/sexual orientation/gender identity.

## Aircraft**Bluebook**





aircraftbluebook.com

AVIATION WEEK

www.AviationWeek.com

## CONTACT US AVIATIONWEEK & SPACE TECHNOLOGY

#### **ADVERTISING**

President/Publisher: Gregory D. Hamilton; +1 (212) 204-4368; hamilton@aviationweek.com

Managing Director, Global Media: lain Blackhall (U.K.); +44 (0)20 7975 1670; iain.blackhall@aviationweek.co.uk

#### U.S. Sales Offices

Managing Director, Americas: Beth Wagner; (703) 997-0261; beth.wagner@aviationweek.com

Director, Commercial Sales: Tom Davis; (469) 854-6717; tom.davis@aviationweek.com

Team Leader, Strategic Accounts: Matt Holdreith; (646) 719-0767;

matt.holdreith@aviationweek.com

Northeast U.S.: Beth Eddy; (561) 279-4646; betheddy@aviationexhibits.com

Northern Midwest to Northwest U.S.: Leah Vickers; (949) 481-4519; leah.vickers@aviationweek.com

Southeast: Rob Howlett; (440) 539-0728; rob.i.howlett@penton.com

Southern Midwest to Southwest U.S.: Miguel Ornelas; (661) 480-7000; miguel.ornelas@penton.com

Canada: Richard Brown; (416) 259-9631; r.brown@vicbrownmedia.com

**Digital:** Jason Washburn; (216) 931-9161; jason.washburn@penton.com

#### International Regional Sales Offices

Publisher, Defense, Space & Security: Andrea Rossi Prudente (U.K.): +44 (207) 182 4524; andrea.rossiprudente@aviationweek.co.uk

Strategic Account Manager: Ann Haigh; +44 (0)1628 526324; ann.haigh@penton.com

Europe: David McMullen; +44 (0)1925 596176; david.mcmullen@aviationweek.co.uk

Asia-Pacific: Hazel Li; +65 67282396; hazelli@outlook.sg Japan: Yoshinori Ikeda;

+81 3 3661 6138; pbi2010@gol.com

+972 (9) 8911792; eshel\_tamir@yahoo.com

MRO Sector, Europe, Middle East: Michael Elmes, Aerospace Media (U.K.); +44 1206 321639; mike.elmes@aerospacemedia.co.uk

#### **Business/Production**

Group Production Manager: Carey Sweeten; (913) 967-1823; carey.sweeten@penton.com

Advertising Operations Manager: Michael Penelton; (913) 967-7449: michael.penelton@penton.com

Production Coordinator: Kara Walby; (913) 967-7476; kara.walby@penton.com

#### Advertising/Marketing Services

For Media Kits, Promotions or Custom Media: www.aviationweek.com/mediakits or Elizabeth Sisk; (860) 245-5632; elizabeth.sisk@aviationweek.com

Advertising Operations Manager: Casey Carlson; (610) 373-2099; casey.carlson@aviationweek.com

#### SUBSCRIPTIONS & CUSTOMER SERVICE

#### Subscriber Service

U.S.: (800) 525-5003 Outside the U.S.: +1 (847) 763-9147; Fax: +1 (844) 609-4274 Outside the U.S. Fax: +1 (847) 763-9682 Email: awstcustserv@halldata.com

Subscription Inquiries: Address all inquiries and requests to Aviation Week & Space Technology, PO. Box 1173, Skokie, IL 60076-8173. Include address label from recent issue when writing. Allow three to six weeks for address change. Include both old and new address and zip or postal codes.

Manage your Subscription (and claim Digital Edition) at: aviationweek.com/awstcustomers

Register & claim access to AWST Online at: aviationweek.com/awstregister

#### **Digital/Online Access**

Support Service: (800) 525-5003 (within the U.S.); +1-847-763-9147 Email: awstcustserv@halldata.com Web: aviationweek.com/awst Subscribe at: aviationweek.com/awst Manage your Subscription: aviationweek.com/awstcustomers

#### Single Copy Sales

Toll-free (U.S. only): (800) 525-5003 Outside the U.S.: +1 (847) 763-9147 Fax: +1 (844) 609-4274

#### Subscription Information for other Aviation Week Products

Aviation Week Intelligence Network, MRO Prospector and Fleet Data: (866) 857-0148 or outside the U.S.: +1 (847) 763-9147.

Fax: (844) 609-4274 or outside the U.S.

+1 (847) 763-9682

Web: aviationweek.com/awin

Email: aw\_intelligence@aviationweek.com

Business & Commercial Aviation: (800) 525-5003 or +1 (847) 763-9147

#### SPECIAL PRODUCTS & SERVICES

#### **Conferences/Exhibitions**

www.aviationweek.com/events:

To Sponsor/Exhibit: Beth Eddy; (561) 862-0005; betheddy@aviationexhibits.com

To Register: Virginia Gongora; (212) 204-4202; virginia.gongora@aviationweek.com

#### AW&ST Mailing List Rental and Sales

Mary Ralicki; (212) 204-4284; mary.ralicki@penton.com

Justin Lyman; (913) 967-1377; justin.lyman@penton.com

#### Reprints, Photocopies and Permissions

Custom Reprints: Brett Petillo; bpetillo@wrightsmedia.com

Wright's Media, 2407 Timberloch Place, Suite B The Woodlands, Texas 77380

Office: (281) 419-5725 Toll Free: (877) 652-5295 Cell: (281) 853-5434 Fax: (281) 419-5712 www.wrightsmedia.com

**Black and White Photocopies:** Copyright Clearance Center; (978) 750-8400; www.copyright.com

Copying without the express permission of the Copyright Clearance Center or Penton Media is prohibited.

#### Social Media

Join the conversation! Follow us at: linkedin.com/company/aviation-week Twitter.com/AviationWeek Facebook.com/AvWeek YouTube.com/AviationWeek

For more information visit us online at

#### www.aviationweek.com/awst

Aviation Week & Space Technology February 20-March 5, 2017 VOL. 179, NO. 04 (ISSN 0005-2175) 1166 Avenue of Americas, New York, N.Y. 10036

Member of Audit Bureau of Circulations and Magazine Publishers of America. Published bi-weekly, with 2 issues in December by Penton Media Inc., 9800 Metcalf Ave, Overland Park, KS 66212-2216. Periodicals postage paid at Kansas City, MO and additional mailing offices. Canada Post International Publications Mail Product Sales Agreement No. 40026880. Registered for GST as Penton Media, GST # R126431964. Title reg.\* in U.S. Patent Office. Copyright© 2017 by Penton Media. All rights reserved. All rights to these names are reserved by Penton Media. **Postmaster:** Send address changes to Aviation Week & Space Technology, Attention: Subscription Services, P.O. Box 1173 Skokie, IL 60076.

# Penton<sup>®</sup>



## Aviation Week Network Events deliver the professional development you need.

- Face-to-face communication
- High-level content
- Relationship building

#### Learn more! aviationweek.com/events

Powered by **Penton**\*

#### **Future Events**

March 2—Aviation Week Laureate Awards. Washington.

- March 8-9-MRO East Asia. Seoul.
- March 13—SpeedNews 7th Annual Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.
- March 13-15—SpeedNews 31st Annual Commercial Aviation Industry Suppliers Conference (ASC). Beverly Hills, California.
- March 28—ATW's Airline Industry Achievement Awards. New York.
- April 11-12—Airline Engineering & Maintenance: Middle East. Abu Dhabi.
- April 25-27-MRO Americas. Orlando, Florida.
- April 26-27—MRO Military. Orlando, Florida.

#### **ADVERTISERS IN THIS ISSUE**

2017 Military Fleet
& MRO Forecast
Aero Montreal
Alcoa2nd Cover
ATM World Congress27
Aviation Week Events
MRO Americas51
ATW Airline Awards3rd Cover
Aviation Week Network5*
Boeing
Breitling4th Cover
Komy
LAAD Aerospace &
Defense & Security25
L-3

Meggitt 15
Space Symposium29
SpeedNews6
20 Twenties
CLASSIFIED ADVERTISING63

Abaris	
Innovative Solutions and Support63	
Longxi Bearing USA63	
Matec	
UPS	

\*Nondefense Demo \*\*Defense Demo

## **Aerospace Calendar**

To submit Aerospace Calendar Listings Call +1 (703) 997-0227

email: aero.calendar@aviationweek.com

Feb. 25-July 22—AOPA Flight Instructor Refresher Course. Various Locations. See aopa.org/forms/event-calendar/FIRC\_ ONSITE

**Feb. 26-28**—Space Exploration Alliance 2017 Legislative Blitz Conference. The Halls of Congress. Washington. See spaceexplorationalliance.org/blitz

Feb. 27-March 1—NASA's Planetary Science. NASA Headquarters. Washington. See hou.usra.edu/meetings/V2050

Feb. 28-March 5—Avalon 2017/Australian International Airshow and Aerospace & Defence Exposition. Avalon Airport. Geelong, Australia. See airshow.com.au/ airshow2017/TRADE/index.asp

March 2—U.S. Chamber of Commerce 2017 Aviation Summit. Omni Shoreham Hotel. Washington. See uschamber.com/ event/2017-aviation-summit

March 2-3—CAPA Airline Fleet & Finance Summit. The Knolls. Singapore. See capaevents.com/ehome/index. php?eventid=199611&

March 4-11—IEEE Aerospace Conference. Yellowstone Conference Center. Big Sky, Montana. See aeroconf.org

March 5-7—ISTAT Americas 2017. Hilton San Diego Bayfront. San Diego. See istat.org/Americas

March 5-7—Business Aircraft Finance, Registration & Legal Conference. Hyatt Regency Coconut Point Resort. Bonita Springs, Florida. See nbaa.org/events/ finance-registration-legal-conference/2017

March 6-9—2017 HAI Heli-Expo. Kay Bailey Hutchison Convention Center. Dallas. See heliexpo.rotor.org

March 6-9—21st AIAA International Space Planes and Hypersonic Systems and Technology Conference (Hypersonics 2017). Science and Arts Center, University of Xiamen. Xiamen, China. See hypersonic2017.xmu.edu.cn

March 13-16—AEA International Convention and Trade Show. Ernest N. Morial Convention Center. New Orleans. See aea.net/convention/2017



## Viewpoint

# Reauthorize? No, Modernize

#### BY BILL SHUSTER

The U.S. House of Representatives' Transportation and Infrastructure Committee is focused on building a 21st century infrastructure for America. The U.S. is stuck with policies and processes developed in the 20th century, and witnesses from the business world warn that unless we act, American competitiveness and economic standing will lag behind more forward-thinking countries. This is particularly true for aviation. A failure to update the U.S. aviation system threatens our competitiveness in the global economy. Our aviation subcommittee is determined to address these concerns. It is focusing on a comprehensive reform of the FAA, the agency's regulatory processes and air traffic services.

America has been the gold standard in aviation since pioneering manned flight over a century ago. Increasingly, however, we are seeing our leadership erode through inefficient processes and a lack of vision and bold action. This must change.

Thankfully, change is in the air. We have a president who has stated his intention to transform the way government operates across the board. In the wake of his meeting with airport and airline executives in the first weeks of his presidency, Donald Trump appears focused on fixing an antiquated aviation system and the bureaucratic morass that holds it back.

Our committee's goal is to provide those overdue fixes. We seek to cut the red tape in the FAA's bureaucratic certification and regulatory processes. Since all new aircraft and aviation products are subject to FAA certification prior to their sale and use, the efficiency of the agency's procedures has a very meaningful impact on U.S.-based manufacturers' ability to innovate, produce and market equipment at a cost that keeps our aircraft and their related goods competitive.

Aerospace manufacturing supports millions of jobs and contributes billions of dollars to the economy. But the U.S. faces intensifying competition from other countries such as China, France, Brazil and Canada. Every unnecessary delay in the certification processes creates a distinct disadvantage for our job creators. By the time a U.S. company's product is certified, the technology may already be out of date.

We have a very safe system, and the FAA, working with industry and labor, must ensure that the highest level of safety is maintained. However, the status quo is untenable. In the high-tech economy, speed determines the winners and losers, and we must streamline and modernize our regulations to allow U.S. companies to compete globally and get their products to market quickly and safely.

Our aviation subcommittee will also focus on other aspects of our aviation system that need to be overhauled. The U.S.'s outdated air traffic control service continues to suffer under an unstable, politicized federal budget process and a poorly managed, wasteful modernization program.

While certification and safety oversight should remain an FAA function, air traffic service is another matter. There is near universal frustration with the snail's pace of the FAA's NextGen program. After spending more than \$7 billion, we have far too little to show. Program costs continue to skyrocket, schedules and deadlines keep slipping, and NextGen has devolved into an expensive and needlessly protracted maintenance program. While other nations race toward situational awareness of their airspace through satellite-based technology, U.S. air traffic controllers use old-fashioned radar and paper strips, and they work in outdated, run-down facilities.

More than 60 nations have sepa-



## Too often the FAA operates like a bureaucratic leviathan instead of keeping pace with the speed of modern innovation.

rated their regulators from their air traffic service providers. To remain competitive in aviation, the U.S. must realize that the federal bureaucracy's inherent political and budgetary instability is unsuitable to operating a high-tech service, and we must adopt what has become the international standard.

These kinds of reforms will form the pillars of the Transportation and Infrastructure Committee's FAA reauthorization proposal this year. We will use last year's committee-passed bill—the Aviation Innovation Reform and Reauthorization Act—as our starting point, but we are open to any suggestions that will improve the bill. Our goal is to complete action on the FAA reauthorization before Sept. 30, the expiration date of the current law.

We need to act now to streamline FAA certification and regulatory processes; provide for modern, efficient, safe air traffic services; and safely integrate drones into the national airspace. If the U.S. is to thrive, we must be leaders in developing the world's 21st century aviation system. ©

Bill Shuster, a Republican of Pennsylvania, is chairman of the U.S. House of Representatives' Transportation and Infrastructure Committee.



### **Reserve Your Place!**

## 43rd ATW Airline Industry Annual Achievement Awards

### March 28, 2017 • J.W. Marriott Essex House • New York, NY

ATW Airline Industry Awards are the most coveted honor an airline or Individual can receive.

## Celebrate with ATW! 2017 Award Winners:

- ▶ Airline of the Year American Airlines
- Airline Market Leader Air Serbia
- ▶ Value Airline of the Year Volaris
- ▶ Eco-Airline of the Year United Airlines
- Eco-Company of the Year AltAir Fuels
- Onboard Experience Achievement Singapore Airlines
- Aviation Technology Achievement NAVBLUE
- Airport of the Year Pittsburgh International Airport
- Excellence in Leadership John W. Crichton

For more information on sponsorship opportunities, or attending the awards ceremony and seminar, visit:

### atwonline.com/awards

AWARDS PLATINUM SPONSOR:

AWARDS SPONSORING PARTNERS:











ECO-AIRLINE OF THE YEAR

AWARD SPONSORS:



March 29, 2017 (Morning following *ATW* Awards)

Hear from global airline CEOs on their challenges and successes in shaping their respective airlines during this half-day event.

#### Speakers include:

- Doug Parker, Chairman and CEO of American Airlines (invited)
- Enrique Beltranena, CEO of Volaris Airlines
- Fred E. Cleveland, Managing Director, Operations, Transportation and Logistics, PwC
- Brian Pearce, Chief Economist, IATA
- Ken McKenzie, SVP Strategy, Airbus Group, Inc.





Aviation enters a new era with a multifunction chronograph delivering unprecedented performance. At the heart of this high-tech feat beats a (COSC) chronometer-certified SuperQuartz<sup>™</sup> movement specially developed by Breitling for aviation. Equipped with a sturdy and light titanium case, the Cockpit B50 innovates with its huge range of functions, extreme user friendliness, rechargeable battery and an ultra-legible high-intensity display mode. Reliable, accurate, efficient: the ultimate pilot's instrument.



BREITLING.COM

INSTRUMENTS FOR PROFESSIONALS™