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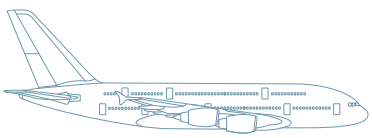

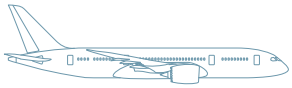

AVIATION WEEK
& SPACE TECHNOLOGY

August 3-16, 2015

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Volume 177 Number 15

AVIATION WEEK
& SPACE TECHNOLOGY

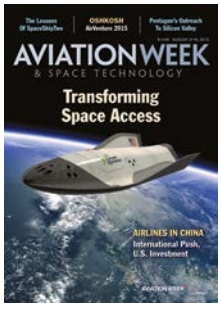
Digital Extras Tap this icon in articles in the digital edition of *AW&ST* for exclusive features.

48 *The Aeroshell team of four T-6 trainers was part of the nighttime aerobatic display that lit up the skies over the 2015 EAA AirVenture in Oshkosh. Other highlights included UAVs, an Airbus A350 flight-test aircraft and an F-35 Lightning II making its first civil air show appearance.*

COMMERCIAL AVIATION

TECHNOLOGY

DEFENSE



ON THE COVER

New technologies that are transforming the space industry are explored in a special report beginning on page 62. On the cover is startup Escape Dynamics' concept for a fully reusable single-stage-to-orbit spaceplane that would be propelled by beaming high-power microwave energy from the ground. Also in this issue are a roundup and pictures from the AirVenture 2015 show in Oshkosh and reports on airlines in China (pages 20 and 52), the SpaceShipTwo accident (page 29) and the Pentagon's outreach to Silicon Valley tech companies (page 58). Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/awst** *and on our app.*

29 ***NTSB report says better*** *design and crew training by SpaceShipTwo manufacturer Scaled Composites could have helped prevent fatal accident.*

40

Feedback

Aviation Week & Space Technology *welcomes the opinions of its readers on issues raised in the magazine. Address letters to the Executive Editor, Aviation Week & Space Technology, 1911 Fort Myer Drive, Suite 600, Arlington, Va. 22209 or send via email to:*
awstletters@aviationweek.com
Letters should be shorter than 200 words, and you must give a genuine identification, address and daytime telephone number. We will not print anonymous letters, but names will be withheld. We reserve the right to edit letters.

MAJOR SHIFT NEEDED

Like Jim McAleese in his Viewpoint "Who's the Boss?" (*AW&ST* July 6-19, p. 74) the major defense contractors know very well who the boss is and for the past decade have followed the boss's direction by enforcing low risk at every level, doing cookbook systems engineering, and enforcing cookbook program management in accordance with Defense Department dogma.

Contractors have learned how to operate in the most centralized defense acquisition environment since the Defense Department was created. For emphasis, Congress jumps in with sequestration—there is not enough money for current programs and certainly none for new ones.

Not surprisingly, defense contractors become very conservative and spend little on R&D. Now the Pentagon pulls a sharp U-turn: Industry, you must crank up R&D spending and develop relevant new technology!

For this to happen, defense industry and Defense Department managers, scientists and engineers must all shift gears—not easy for large bureaucratic organizations. Management of the total effort must be decentralized. Most important, Defense and each military department must set a coherent set of strategic objectives to guide the effort.

We know who the boss is. Much more than a directive to simply spend more on R&D is imperative. The boss needs to step up.

Sherman N. Mullin
OXNARD, CALIFORNIA

ATMOSPHERIC ENERGY

There is more than one way of extracting energy from the atmosphere when wind velocities are different at different altitudes. Albatross and radio-controlled model gliders use dynamic soaring to stay aloft indefinitely.

The Embry-Riddle Aeronautical University Dual-Aircraft Study noted in "Sky-High Ideas" (*AW&ST* July 6-19, p. 44) should compare the two methods using equivalent levels of technology to determine which has the better chance of success.

Tony Hays
SAN CLEMENTE, CALIFORNIA

DOES FORTUNE FAVOR THE F-35?

I remember hearing a rule of Project Management that went something like this: "Fast, Cheap, or Good—you can have any two." Well, it seems as if the F-35 program is now going to sorely test that rule.

It hasn't been fast—development of this version was started in 2001 and it is still not operational. It isn't cheap—the December 2014 Statement of Acquisition Reports lists program costs of $391.1 billion. And good? "No Prize for Second Place" (*AW&ST* July 20-August 2, p. 57) indicates that a 20-year-old F-16 can out-fly it. Although all aircraft development programs have issues, this one seems to have a particularly charmed life. Why?

Fred Furtek
BALDWINSVILLE, NEW YORK

LOCKHEED MARTIN/TOM REYNOLDS

F-35 GEARED TOWARD OLD WARS

Recent reports on how an F-16 defeated an F-35 in a mock dogfight have proven something I have feared ever since the start of the Joint Strike Fighter program. Sure, Lockheed Martin touts that when in its "full operational configuration/condition" the F-35 is 400% superior in air-to-air combat than most fighters in service today, but I doubt that. One of the company's main arguments is that the F-35 will engage targets at long range, relying on stealth to get that critical first shot.

That was fine for conflicts fought in the past 25 years against inferior opponents. But what happens when we face near-peer opponents, such as Russia or China, which hope to deploy more advanced aircraft in the coming years? In that sort of situation it is not guaranteed that the F-35 will detect the opponent first for that critical first shot. As we learned in the Vietnam War, technology will not get rid of the dogfight and fighters will need agility to survive, as proven with the recent offering of an agility upgrade for the Typhoon.

Jacob Katz
NORFOLK, VIRGINIA

And looping in some related comments from the web:

dutchcanada laments:
I'm hoping Canada dumps this beast. [It's not] even on par with current fighters. . . . Is there no commonsense in Washington to kill this just-so-failed project?

jgberson@rogers.com concurs:
Totally agree. The F-35 A, B or C is not suited to real Canadian needs. Best to get more F/A 18s—much more appropriate to the types of missions this country will be called on to perform.

And a more general response from **Jeneral28**:
F-35 supporters say the report is trash; F-35 haters love it. End of the day—no one is right.

tintruder posits:
How do you propose they fix the energy deficit? Where is the extra 15,000 lb. of thrust going to come from—hang extra jet engines under the wings like on the B-36?

Warrent9 responds:
The GE Advent engine will get you most of the way there, and add range, and perhaps supercruise to boot.

26981@sbcglobal.net avers:
Australia acts like America's 51st state. If it was independent it might have bought the Russian fighter—which has superior performance compared with the U.S. aircraft.

Correction: *The letter:* The Up- and Downside of Gulf Carriers *was amended online to better reflect the writer's intent.*

Who's Where

R. Narasimhan

Georges Biwer

A. Nunes Pereira

Joao De Toni

Gerardo Tellez

Elizabeth Bierman

Kate Rubens

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* AWIN.AviationWeek.com *For information on ordering, telephone U.S.: +1 (866) 857-0148 or +1 (515) 237-3682 outside the U.S.*

John Luddy has been appointed vice president-national security and acquisition policy, William "Doc" Syers vice president-legislative affairs, and Paul Paolozzi vice president-communications at the *Aerospace Industries Association* (AIA). Luddy joins AIA from his consulting practice, Vector Solutions, whose clients included Raytheon Missile Systems, Northrop Grumman and the U.S. Missile Defense Agency. Syers had been vice president for congressional relations at ITT/Exelis. Paolozzi had been initiatives group chief for the Under Secretary of the Army.

Rakesh Narasimhan (see photo) has been named executive vice president and general manager of engineering, sales, marketing and operations at *BlackSky Global*, a satellite imaging company that aims to orbit a 60-satellite constellation by the end of 2019. Narasimhan had been group vice president and general manager of Citrix Systems, a multinational software company.

Mark Jenks has been named head of Seattle-based *Boeing Corp.*'s 787 Dreamliner program. He succeeds Larry Loftis, who retired on July 31. Jenks's responsibilities include reducing the $27 billion in combined unit losses that have accumulated during 787 production. He had been program deputy general manager.

Bruce Walker has been appointed vice president-homeland security, civil, regulatory and international affairs at *Northrop Grumman Corp.*, Falls Church, Virginia. His recent positions with the company include working with the Federal Agencies Integrated Customer team.

Nina Jonsson has been named *Air France-KLM Group* senior vice president-fleet management, and **Adeline Challon-Kemoun** executive vice president-marketing, digital and communications. Challon-Kemoun had been senior vice president-corporate communications at Air France.

Jason Christopher Holt has been appointed executive vice president-flight operations, and **Claude Zehren** deputy head of flight operations at *Cargolux Airlines International*, headquartered in Luxembourg. Holt begins his new position in the fourth quarter, and comes to Cargolux from EasyJet Airlines, where he had been head of Gatwick operations and operational strategy. Zehren was most recently chief pilot at Cargolux.

U.S. Navy Rear Adm. (lower half) **Brian K. Corey** has been assigned as commander *Naval Air Warfare Center*, Weapons Div., and assistant commander for test and evaluation *Naval Air Systems Command*, China Lake, California. He has been vice commander, Naval Air Systems Command, Patuxent River, Maryland.

U.S. Navy Rear Adm. (lower half) **Michael T. Moran** has been assigned as program executive officer for *Tactical Aircraft Programs*, Patuxent River, Maryland. Moran had been commander, Naval Air Warfare Center, Weapons Div., and assistant commander for test and evaluation, Naval Air Systems Command, China Lake, California.

Georges Biwer (see photo) has joined *AirBridgeCargo Airlines* as vice president-Europe, the Middle East and Africa. Russian parent Volga Dnepr Group has charged Biwer with expanding the company's cargo operations within Europe and across other regions.

Alexandre Nunes Pereira, Joao De Toni and **Gerardo Tellez** (see photos) have been named *Gulfstream Aerospace Corp.* field service representatives in Latin America. Pereira and De Toni are based in Sao Paulo, and Tellez is based in Toluca, Mexico. Pereira had been a field service rep for Embraer in the region. De Toni was a field service rep specializing in avionics technical support for Honeywell Aerospace, South America. Tellez had been maintenance director for a charter company in Toluca.

The Aerospace Technology Institute (ATI), a think tank for the U.K. aerospace and technology industries announced seven hires in engineering, finance and communications: **Richard Wilson,** lead technologist, whole aircraft; **Paul Clarke**, lead technologist-technology, strategy and integration; **Edward Andrews**, technologist-strategy and integration; and **Ruben Alcolea**, technologist. **Michaela Little** has joined ATI as controller; **John Warehand** has been appointed head of communications and **Peter Willis** economist.

Andrew Jazwick has been named vice president-operations for *CAE* Defense and Security, which trains civil aviation, defense and security personnel. Jazwick is the unit's senior executive in Washington, where his duties include representing the company to Congress, federal agencies, foreign governments and industry associations. He had been most recently corporate vice president-legislative affairs for Cubic Corp.

HONORS AND ELECTIONS

Elizabeth Bierman (see photo), **Bobak Ferdowsi, Kathleen "Kate" Rubens** (see photo), and **Susanna Phillips** have been inducted into the *Space Camp Hall of Fame* by the U.S. Space & Rocket Center. Bierman is a senior project manager at Honeywell Aerospace and national president of the Society of Women Engineers. Ferdowsi is a flight engineer at NASA Jet Propulsion Laboratory. Rubens is a NASA astronaut scheduled to fly to the International Space Station in 2016. Phillips, who is a native of Huntsville, Alabama, home of the Space and Rocket Center, is a soprano with the Metropolitan Opera.

Kathy N. Waller has been named to the board of directors of *Delta Air Lines*. Waller is executive vice president and CFO of Coca-Cola Co.

RAYMOND WAE TION/MAXAPPP/LANDOV

COMMERCIAL AVIATION

Evidence is strengthening that a section of airfoil found washed ashore on Reunion Island on July 29 is a flaperon from a Boeing 777, presumably Malaysia Airlines Flight 370 (MH370), which disappeared on March 8, 2014. Barnacles indicate the debris has been floating some time, and Indian Ocean currents suggest the part could have drifted from the arc west of Australian where the search for MH370 is focused. For updates, see **AviationWeek.com/mh370**

FedEx Express has ordered an additional 50 Boeing 767-300F freighters, with options on another 50. The firm-order aircraft will be delivered from 2018 to 2023 and take FedEx's 767 fleet to 106. China's largest freight operator, SF Express, will likely order 30 767-300Fs this year.

Boeing projects worldwide demand for 558,000 commercial pilots and 609,000 maintenance technicians in 2015-34 as airlines add a forecast 38,000 aircraft to the global fleet. Pilot demand is up more than 4% from last year's forecast and technician demand by about 5%.

Delta Air Lines plans to acquire a 3.55% stake of China Eastern Airlines for $450 million, strengthening the SkyTeam alliance in China's growing business-travel market. Delta has small stakes in AeroMexico and Brazil's GOL and owns 49% of the U.K.'s Virgin Atlantic Airways (page 20).

Airbus says it will deliver the first A320neo to launch customer Qatar Airways before year-end after resuming flight testing of the Pratt & Whitney PW1100G-powered variant on July 27. Flight tests had been grounded for three months after discovery of a snap-ring failure in the combustor section.

A European Commission task force formed in the wake of the Germanwings Flight 9525 crash has recommended more robust screening of pilots, drug and alcohol programs with random testing, strengthened aeromedical examiner oversight and a European aeromedical data repository (page 32).

DEFENSE

BELL HELICOPTER

Japan has selected Fuji Heavy Industries to supply the Ground Self-Defense Force's UH-X utility helicopter, based on the proven Bell 412EPI, securing Fuji's future as a helicopter builder while minimizing program risk. Production of 150 helicopters is to begin in 2021 (page 44).

First deliveries of Embraer's KC-390 tanker/transport to the Brazilian air force have been delayed to first-half 2018, from 2016, by cuts in defense spending. The first prototype, which flew once in February, will resume flight tests in the third quarter, and Embraer now expects certification in second-half 2017.

Russia is preparing to restart production of the Tupolev Tu-160 supersonic bomber, last built in 1992. The updated Tu-160M2 will enter production in 2023, preceded by reengining of the current 15-aircraft fleet with upgraded Kuznetsov NK-32.02s to increase range by 1,000 km (621 mi.).

Royal Australian Air Force electronic-attack Boeing EA-18G Growlers

BOEING

will be carrying the Raytheon ATFLIR pod to validate targets and AIM-9X air-to-air missiles for self-defense, additions the U.S. Navy is looking at. The first of 12 Australian Growlers rolled out July 30, for delivery in 2017 after testing in the U.S.

A laser-armed Block 60 version of the Lockheed Martin AC-130J gunship could be operational by 2020, says U.S. Air Force Special Operations Command. Some Block 60s could carry a high-energy laser, others a longer-range version of the Active Denial millimeter-wave "pain ray."

The first three of 24 Dassault Rafale fighters for Egypt were handed over on July 20. The contract signed

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First Take

in February called for six aircraft that had been intended for France to be diverted to Egypt. Qatar signed a 24-aircraft order in May but does not require such rapid delivery (page 41).

A Greek Lockheed Martin F-16D that crashed in Spain on Jan. 26, killing the two pilots and nine French airmen on the ground, was incorrectly trimmed as it took off, say French investigators. The aircraft yawed heavily to the right, crashing into a crowded ramp at Albacete air base.

BUSINESS AVIATION

Entry into service of Bombardier's Global 7000 large-cabin, long-range business jet has been delayed to second-half 2018, from 2016, the Canadian manufacturer citing development challenges. The first flight-test aircraft is in assembly at Toronto. No date is given for Global 8000 service entry, which has been 2017.

AgustaWestland has received European certification of the AW169

AGUSTAWESTLAND

medium twin-helicopter, originally expected in 2014. Production is underway in Italy, and a second assembly line is being established at the company's Philadelphia plant.

Textron Aviation, owner of Cessna and Beechcraft, plans to develop a new single-engine turboprop, with a 1,500-nm range and cruise speed exceeding 280 kt. General Electric, meanwhile, is defining a clean-sheet 2,000-shp turboprop engine to complete with Pratt & Whitney Canada's PT6A.

SPACE

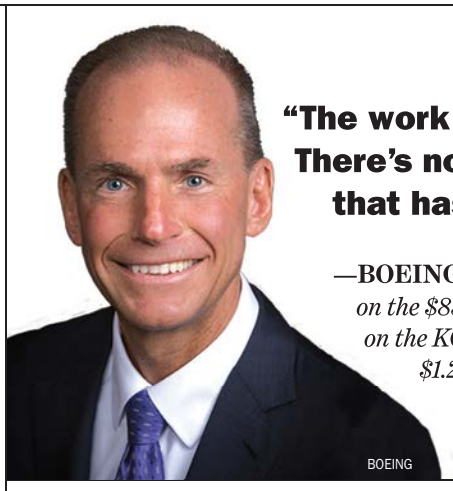
The co-pilot's earlier-than-planned unlocking of the feathering tail mechanism on SpaceShipTwo (SS2) probably caused the suborbital vehicle's fatal crash on Oct. 31, 2014, says the NTSB. Investigators also criticized developer Scale Composites' aircrew procedures (page 29).

Airbus Defense and Space is to lead development of the European Space Agency's Jupiter Icy Moons Explorer (Juice) spacecraft under a €350.8 million ($388 million) contract. To be launched in 2022, Juice will conduct the first thorough exploration of Jupiter's moons since NASA's Galileo mission launched in 1989.

AIRBUS DEFENSE & SPACE

DIED

Avul Pakir Jainulabdeen Abdul Kalam, India's father of missile technology and former president, died on July 27. As a scientist and administrator at the Defense Research and Development Organization and Indian Space Research Organization, Kalam led development of the Agni and Prithvi missiles and India's first indigenous satellite launch vehicle.



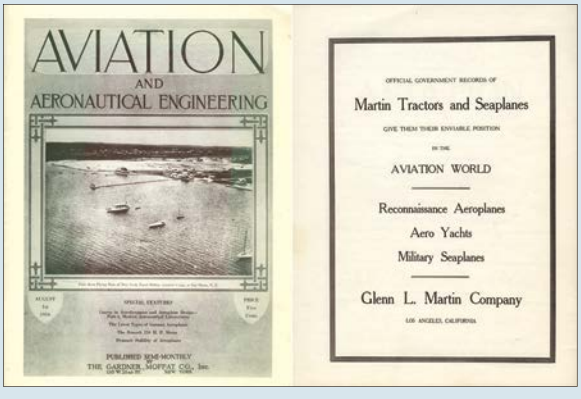
BOEING

QUOTED

"The work to go is well understood. There's no technology or invention that has to be accomplished."

—BOEING CEO DENNIS MUILENBURG, *on the $835 million pretax charge Boeing took on the KC-46 tanker program. Boeing has taken $1.26 billion in pretax charges since it beat Airbus for the tanker contract in 2011 (page 26).*

99 YEARS AGO IN *AW&ST*



The first issue of *Aviation Week & Space Technology,* then a "semi-monthly" called *Aviation and Aeronautical Engineering,* was published on Aug. 1, 1916. The cover featured a photo of ships taken from an airplane, and the issue included features on "the latest types of German aeroplanes"—World War I was raging across Europe—and the Renault 220 H.P. Motor. The back of the 34-page issue featured an advertisement for reconnaissance airplanes, aero yachts and military seaplanes built by the Glenn L. Martin Co. of Los Angeles, which is still in business today as Lockheed Martin. The magazine changed its name to *Aviation Week* in 1947 and to *Aviation Week & Space Technology* in 1960.

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By Richard Aboulafia

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

COMMENTARY

Missed Opportunities

KC-46 falls flat in international market

This summer saw two aerial refueling tanker-market developments that were predictable yet important. The first was another Boeing loss for its KC-46 development program. The second was another export victory for Airbus's KC-30. These two events suggest how this market will evolve over the next decade or so.

In July, Boeing announced another charge on its KC-46 development program, this time for $835 million (pre-tax) or $536 million (after tax). The total forward loss on this program is now up to $1.26 billion (pre-tax) or $808 million (after tax). The only positive news is that the latest loss moves the total program development cost to $6.16 billion. This is close to the program office's current completion estimate of $6.3 billion. But as a Bank of America/Merrill Lynch analyst note put it, "We fail to understand how Boeing could take a $1.26 [billion] pre-tax charge on the Boeing KC-46A program since the program is based on the 767 airframe that has been in production for over 30 years."

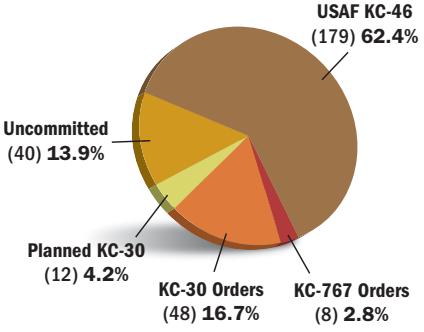
A few weeks before the loss announcement, South Korea chose the KC-30 over the KC-46A for a four aircraft requirement. At the same time, Australia added two more KC-30s to its previous five-aircraft order.

Boeing has not won a single international KC-46 order thus far; the KC-30 now has 48 orders. Another 12 are being negotiated, with India, Qatar and South Korea. KC-46 development problems seem to be undermining Boeing's marketing efforts.

Airbus now has nine firm and imminent KC-30 customers, which virtually guarantees a string of follow-on buys. This raises the question of the total world tanker market, and Boeing's hopes of addressing it.

Boeing has estimated total global tanker demand at $80 billion. Yet in reality this is a new and somewhat immature market. Until 2001, the pool of customers willing to spend money on Western new-build jet tankers was limited to one. While many countries maintained some kind of air-to-air refueling capability, only Saudi Arabia had actually purchased them new (in the form of eight 707s built as KE-3s). Even the U.K. Royal Air Force, the biggest tanker user outside the U.S., used converted Lockheed L-1011s and Vickers VC-10s.

Current Generation Jet Tanker Markets



Source: Teal Group

All other tanker users also operated either converted used civilian jetliners or KC-135s previously owned by the U.S. Air Force. France, for example, uses the KC-135R, and Turkey and Singapore have received them, too. Other countries use turboprop tankers, most notably Lockheed Martin's KC-130.

In 2001, the Italian air force signed for the first new-generation, new-build tanker, Boeing's KC-767. This purchase of four aircraft was followed by a Japanese purchase of four later that year. Thus the pool of new-build jet tanker customers tripled in one year. But Boeing had serious cost overruns and execution problems with these aircraft, a harbinger of things to come.

Looking at current plans and recent trends, we can forecast only another 40 new tanker sales over the next 10 years. Some will come from current KC-30-user countries. Some also will be for used aircraft. Israel Aerospace Industries has developed a Boeing 767 tanker/transport conversion, with recent sales to Colombia and Brazil.

Also, time is not on Boeing's side. In 2017, Airbus's A330neo will enter service, offering newer engines with better performance and lower fuel burn. Given the minimal change to the A330neo, it's probably a matter of a few years before the KC-30 also becomes the KC-30neo. There are no plans to upgrade the 767, meaning the KC-46 will be at a disadvantage.

Meanwhile, the 787's carbon-fiber composite airframe could complicate efforts to turn it into a tanker, and it is unlikely that the Defense Department, or anyone else, would pay the development bill. The same is true for the 777, which is even less likely to become a tanker because it will be replaced by the 777X, which is probably too big to make an appealing tanker.

On the other hand, once the KC-X program gets to full rate, it will be difficult to stop. The last of 179 aircraft won't be delivered until around 2027. By then, the remaining fleet of more than 200 KC-135s will average upwards of 60 years in age. The KC-10 fleet will be around 40 years old. The idea of stopping a hot production line and beginning a completely new tanker acquisition effort (the notional KC-Y) will not be appealing to the Air Force. Meanwhile, the political constituency built up around the KC-46 will work to keep funding in place for additional aircraft.

Thus if current trends persist, Airbus will keep dominating the international tanker market, while Boeing continues to dominate the U.S. market. This will be a rare example of a program where the U.S. military stamp of approval confers no special advantage with export customers. But at least Boeing will likely get through the current KC-46 development phase losses and ultimately turn a respectable profit on this domestic market.

By Joseph C. Anselmo

Follow Editor-in-Chief Joseph C. Anselmo on Twitter @AvWeekJoe

COMMENTARY

Will Boeing Take a Hike?

Why Congress's puerile dithering threatens U.S. aerospace jobs

During his 10 years as Boeing's CEO, Jim McNerney was resolute that the company would not offshore major operations. When I asked him two months ago about the possibility of assembling Boeing airliners in China, where rival Airbus already has a plant, he was almost dismissive. "You know, my thinking really hasn't changed," he replied.

But McNerney, who recently stepped down as CEO—while retaining his role as chairman—made an about-face last week. If Congress cannot find a way to reauthorize the U.S. Export-Import Bank (Ex-Im), which has been unable to underwrite new loans since its charter expired on June 30, Boeing might take its jobs elsewhere.

Senators Who Voted Against Reauthorizing the Ex-Im Bank

Barrasso (R-Wyo.)	Gardner (R-Colo.)	Sanders (I-Vt.)
Boozman (R-Ark.)	Grassley (R-Iowa)	Sasse (R-Neb.)
Capito (R-W.Va.)	Hatch (R-Utah)	Sessions (R-Ala.)
Cassidy (R-La.)	Inhofe (R-Okla.)	Shelby (R-Ala.)
Cornyn (R-Texas)	Lankford (R-Okla.)	Sullivan (R-Alaska)
Cotton (R-Ark.)	Lee (R-Utah)	Thune (R-S.D.)
Crapo (R-Idaho)	McConnell (R-Ky.)	Tillis (R-N.C.)
Cruz (R-Texas)	Paul (R-Ky.)	Toomey (R-Pa.)
Daines (R-Mont.)	Perdue (R-Ga.)	Vitter (R-La.)
Fischer (R-Neb.)	Risch (R-Idaho)	

Source: U.S. Senate

"I'm beginning to think that maybe I made the wrong decision," he told the Economic Club of Washington on July 29, warning that Boeing might move "key pieces" outside the U.S. "Our prior plan was to build everything in the U.S. and export. We've got to think about this. Maybe there are export credits somewhere else."

The Ex-Im bank supports the export of U.S.-made products by guaranteeing loans made to overseas customers to buy those products. And Boeing, which had exports of $52.9 billion last year, is by far the bank's biggest beneficiary. To Ex-Im critics such as Sen. Ted Cruz, the bombastic Republican from Texas who is running for president, that smacks of crony capitalism and government meddling in markets. On July 27, the Senate voted 64-29 to reauthorize the bank. But the highway bill the measure was attached to was not taken up by the House, meaning any resolution on the Ex-Im will have to wait now that Congress has blown town for its six-week summer holiday. And when it resumes session it will have only a few weeks before the funding that allows the Ex-Im to keep its doors open expires on Sept. 30.

It's not as if McNerney can make good on his threat anytime soon. Airplane factories require massive capital investments and specialized labor. You can't just pick up a narrowbody assembly line and move it like an apparel factory. But Boeing is a stockholder-held business, not a charity. If the Ex-Im bank is allowed to die, McNerney's successor as CEO, Dennis Muilenburg, will certainly have less of an incentive to keep the company's investments and sourcing in the U.S. And that would have a real impact on American exports and employment, considering that about 94% of Boeing's workforce of 163,466 are located in the 50 states.

It is truly mind-boggling that this debate is even going on. As this magazine has noted on its editorial page, the bank costs the government nothing and actually makes a profit. Nearly two-thirds of the Senate has voted to reauthorize the bank, and supporters figure they have about 300 votes in the 435-seat House. But Senate Majority Leader Mitch McConnell (R-Ky.) and House Speaker John Boehner (R-Ohio) allowed the bank's charter to expire, and so far Boehner has not brought the Ex-Im reauthorization up for a vote. Is he really that intimidated by the vocal minority of bank critics?

Those critics complain the Ex-Im is skewing free markets. But the bank's demise would hardly level the playing field. Nearly every industrial nation has an export credit agency similar to the Ex-Im. In 2013, the Ex-Im guaranteed financing for $14.5 billion in new loans. China—which has ambitions to challenge Boeing's and Airbus's dominance of the airliner industry—underwrote $45.5 billion in loans. Germany and France, which share Airbus's headquarters, collectively underwrote $37.1 billion.

In other words, killing the Ex-Im would be unilateral disarmament by the U.S. And Boeing is certainly not the only beneficiary; exports of everything from General Electric aircraft engines to components made by small suppliers would take a hit, and many thousands of jobs would be put at risk. That apparently does not concern the 29 senators who voted against reauthorizing the bank (see table).

Last year, the U.S. ran a trade deficit of $505 billion in commercial goods and services. Commercial aircraft are one of the few industries where the nation enjoys a robust surplus. Reauthorizing an Ex-Im bank that costs the taxpayers nothing and supports well-paying jobs is a no-brainer. Unfortunately, brains don't seem to be carrying the day in Congress.

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By William Garvey
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COMMENTARY

Scary Simulation

A 'secret sauce' for conquering inflight upsets

A new rule from the FAA calls for incorporating upgraded full-flight simulators in upset prevention and recovery training (UPRT), and a FlightSafety International simulator recently became the first approved by the agency to do so.

Ironically, the new FAA rule, which becomes effective in March 2019, applies to the training of Federal Aviation Regulations (FAR) 121 airline pilots only, and the FlightSafety simulator replicates a Gulfstream G550, a jet flown primarily by FAR 91 business and FAR 135 charter pilots, who are unaffected by the rule. Regardless, FlightSafety is embracing it as a higher standard that should be broadly applied across pilot ranks.

Historically, flight simulators have mirrored the performance and behavior of their respective aircraft models at points within the aircraft's operating envelope, ranging from stick-shaker/stickpusher activation stall warning to the maximum certificated airspeed (V_{MO}/M_{MO}). No simulator training beyond those extremes was authorized by the agency.

It was believed that the absence of data points beyond those figures would hamstring simulator makers, forcing them to retest the subject aircraft in extreme conditions. However, it turns out Gulfstream Aerospace does conduct full stalls and flies beyond M_{MO} during certification flight testing, and captures all the related data. This is shared with FlightSafety.

During the subsequent six months, FlightSafety programmers at the company's simulation center in Broken Arrow, Oklahoma, analyzed the data along with the environmental conditions at the time they were captured to determine the aircraft's response under a variety of circumstances since those could, for example, cause a stalling aircraft to break right or left or result in a "falling leaf" stall.

Dann Runik, executive director of advanced training programs, says that

FLIGHT SAFETY INTERNATIONAL

despite this "nonlinearity of data," analysts found the common factors that cause an aircraft to behave seemingly inconsistently and unpredictably in extreme flight conditions. "There is a common element, and we found it."

Consequently the simulator performs in the same manner, surprising and confounding pilots who expect predictability.

"They ask, 'How do you do that?'" Runik laughs. "We're not saying. It's FlightSafety's secret sauce recipe" and thus proprietary, he says.

The company has already launched a one-day UPRT course for the G550 comprising 3.5 hr. of classroom work and 4 hr. in the simulator at its Savannah, Georgia, training center (see photo). The pilots involved in the aircraft's certification flight tests have all flown the simulator and attest to its behavioral accuracy.

The G650 simulator has now been similarly upgraded and FlightSafety plans to do the same for its G450 and, possibly, its G280 simulators as well. The courses will be taught at its other five Gulfstream centers, but only after identifying and indoctrinating its "best of the best" instructors, says Runik. FAA is concerned that done wrongly, a UPRT course could result in a negative transfer of information, which could be more dangerous than no training at all.

The company plans to work with other airframe manufacturers to produce similar cockpit-specific courses.

The courses are available only to pilots type-rated in the aircraft. The classroom session covers aerodynamics, indications and procedures, plus admonitions on the importance of forceful, immediate and seemingly unnatural corrective actions when encountering a stall in a swept-wing transport aircraft: push, level wings, raise the nose, advance throttles.

After the academic portion, pilots enter the simulator where they are confronted by flight upset scenarios that have all ended in fatal crashes. At the FAA's request, the company will not reveal which crashes are involved, to prevent the pilots from preparing responses in advance.

Despite the considerable experience of many pilots in flying the G550, Runik says almost all of them crash during one or more of the scenarios—often during a stall at low level—which comes as a shock to those at the controls. Factors include images through the windscreen unlike any they've encountered in normal flying, including "ground rush," which prompts a pull-back reaction.

Moreover, Gulfstream pilots prize what Runik calls "corporate smooth" control inputs for passenger comfort. Yet upsets demand the pilots "put violence on the airplanes" to recover—a reaction totally foreign to most.

Other training providers who favor using aerobatic aircraft for UPRT sessions say it is the best tool for imparting to the student the high g-loads and disorienting conditions of an upset. But one Gulfstream pilot who had just completed the G550 simulator training notes that the computerized g-meter monitoring his recoveries never exceeded 2.2g and that the visuals were startling.

Other factors favoring the simulator training are the machine's exact replication of an aircraft's cockpit, instrumentation and behavior. And, notably, its ability to simulate low-level maneuvers that would be too dangerous to conduct in an actual aircraft.

Runik says the course—$9,900 for full-service customers—"sells itself."

By Jens Flottau

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LUFTHANSA

COMMENTARY

Turning Point

Lufthansa, Air France pilots indicate they will agree to some concessions

When German pilots union Vereinigung Cockpit (VC) decided in early July to pull the plug on arbitration in its long-standing dispute with Lufthansa, all signs pointed toward a new, 13th round of strikes. Nothing indicated how the airline might come to a desperately needed agreement that would contribute to substantially lower costs, increased competitiveness and a return to growth.

Only a few weeks later, the picture looks quite different. Lufthansa pilots elected a new 16-member commission now in charge of negotiating on their behalf. And although many of its members are not new, its leadership has changed, after veteran chief negotiator Thomas von Sturm decided to end his union career for now. A turn in negotiations was still unexpected, but it came in the form of an open letter to Lufthansa. The proposals have the potential to end the carrier's slow and lasting decline, from a European airline powerhouse to an old-fashioned, high-cost legacy carrier unable to reform. They are therefore highly significant.

The conflict between VC and Lufthansa centered on the creation of the Eurowings low-cost unit, planned to absorb all the nonhub flying, including a small long-haul operation. The Eurowings unit includes several operating carriers such as the former regional airline of the same name, a new carrier created in Austria and long-haul services flown by SunExpress Deutschland. It may also include other Lufthansa Group carriers such as Brussels Airlines or Air Dolomiti. Management wants to keep the unit—aimed at lowering costs around 40%—completely separate from the legacy operation. With no breakthrough deal reached, the plan was to grow Eurowings, shrink Lufthansa and transfer to the new division more unprofitable legacy flying, including long-haul routes. This was viewed as a massive and credible threat to pilots' careers.

The threat was serious enough to be an impetus for changes and VC now seeks to bridge some differences. The union proposes that pay at Eurowings be similar to that at EasyJet and that the unit's long-haul pilots be paid salaries comparable to those at Condor. A separate benchmark study among legacy carriers is to determine the right pay level at Lufthansa's mainline operation. VC also accepts 20% higher productivity as part of the "Jump" project—a 14-aircraft long-haul subfleet geared toward low-yield markets. A higher average retirement age (60) is no longer a major issue, nor are productivity improvements or a temporary wage freeze. VC says it should be possible to reach an agreement on all issues by the end of August.

The proposals were originally part of a February 2015 management initiative to seal an "alliance for growth and employment." Lufthansa suggested it would grow the mainline fleet to 340 aircraft from 313 by 2020 if pilots agreed to cost concessions. VC had not replied to the proposals until now.

If the deal becomes reality, it will put Lufthansa two steps ahead of Air France, where pilots have so far blocked the creation of Air France-KLM's pan-European low-fare unit, Transavia Europe. However, there may be some movement at Air France also. SNPL, the airline's largest pilot union, has indicated under new leadership that it is no longer fundamentally opposed to Transavia—but that the plans should be subject to negotiation. The proposed unit was the cause of a huge two-week pilot strike last year that cost the airline $500 million. Management, under heavy political pressure, was forced to call off the plans, eventually stalling one key Air France-KLM initiative to enter the European direct services market with a more competitive product.

But the key in both cases is not the low-fare business. That part of the market will be dominated by Ryanair, EasyJet and similar carriers. Neither Air France-KLM nor Lufthansa have reacted quickly or effectively enough. They can still hope to create profitable units in the segment but will likely never be the dominating carriers. The key to securing their futures will be the transformation of their legacy hub-and-spoke units. And while Lufthansa's pilots appear to recognize the need for action, their French colleagues are still a long way from the road to sustainability.

By Graham Warwick

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COMMENTARY

Frequency Fight

The threat to GPS from wireless broadband communications has resurfaced

Just when you thought your GPS receiver was safe, LightSquared is back. The company that wants to use frequencies adjacent to GPS for a hybrid terrestrial-satellite broadband mobile communications network is coming out of bankruptcy intent on proving to the Federal Communications Commission (FCC) that its transmissions will not interfere with GPS.

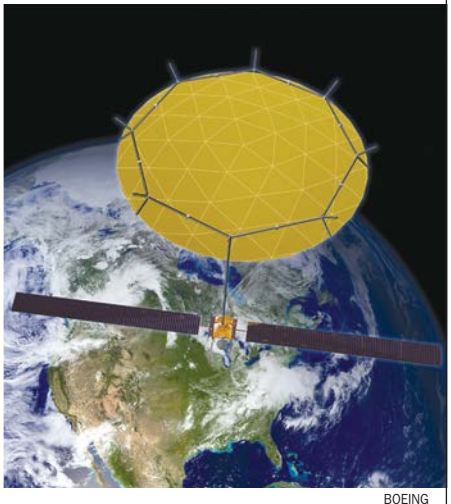
And predictably, LightSquared is again at loggerheads with the GPS community over the extent of any interference, how to measure whether it is harmful and who should do the testing. It was compelling evidence of adverse interference with GPS that forced LightSquared into bankruptcy in 2012, so its existence is again on the line.

LightSquared's original plan was to reuse a block of L-band mobile-satellite spectrum at 1526-1555 MHz for terrestrial wireless communications, but this is close to GPS at 1563-1587 MHz. Testing in 2011 and again in early 2012 showed the powerful base-station transmissions would overload most GPS receivers, and the FCC refused to lift its prohibition on commercial operations by LightSquared.

This forced LightSquared into Chapter 11 bankruptcy protection and a fierce legal battle over ownership of the company and its supposedly valuable spectrum. A plan to exit Chapter 11 was finally approved by the U.S. Bankruptcy Court in March, but the company's business plan is still the same.

And that is because the FCC's conditional waiver allowing LightSquared to use its spectrum for a hybrid network, provided there is no harmful interference with GPS, is still in effect. If the company can prove it can coexist with GPS, then its spectrum could indeed be worth billions of dollars.

LightSquared has adapted its plans since 2012, giving up on using the upper 10 MHz of frequency band closest to GPS (1545-1555 MHz) and putting off using the lower 10 MHz (1526-1536 MHz) until the FCC can rule on its use. The new plan is to use its handset uplink frequencies at 1627.5-1637.5 MHz—farther from GPS—paired with 10 MHz of downlink spectrum made up of 1670-1675 MHz owned by LightSquared and 1675-1680 MHz to be shared with a government user.



BOEING

But the company must still convince the FCC the plan will prevent harmful interference with GPS. When the FCC suspended LightSquared's authorization in 2012, the Transportation Department was tapped to lead a government-industry Adjacent Band Compatibility (ABC) assessment to determine how much power could safely be emitted by users of frequencies close to those used by satellite navigation systems.

The ABC study will test a range of receivers to determine a "mask"—the power level at each frequency that can be emitted without causing interference—but bureaucracy and budget pressures have delayed this. The GPS community is now awaiting publication of Transportation's proposed test plan for public comment, after which the department will finalize its plans and only then begin the trials.

Although testing in 2011-12 showed transmissions in the 1526-1555-MHz band overloaded most GPS receivers, only limited and inconclusive testing was conducted at the higher, 1627.5-1637.5-MHz band. For the GPS community, the government-led ABC study is critical to resolving the issue across all the frequencies that could interfere with navigation-satellite signals.

LightSquared, meanwhile, has lost patience with the delays and plans its own receiver testing. The results will be presented to the FCC in September in a bid to show the new frequency plan complies with the waiver conditions so commercial operations can begin. LightSquared has challenged the legitimacy of a Transportation Department-led study, arguing that only the FCC has jurisdiction over spectrum. The GPS community has defended the multi-stakeholder ABC and attacked LightSquared's test plans, speculating the company is worried that government-led testing will uncover harmful interference even at the higher frequencies.

At issue is how the two test campaigns will measure interference. The ABC study will measure the increase in signal-to-noise ratio using a 1-dB rise in the noise floor—an increase of 25% in GPS bands—as the definition of harmful interference. LightSquared's testing will measure key performance indicators (KPI) for different use cases, including aviation, cellular telephones, navigation and high-precision timing.

The company argues GPS performance is not necessarily directly related to noise rise, and "a 1-dB increase may produce an imperceptible increase in GPS position error or other KPI." The GPS community says the signal-to-noise metric has been used globally for 50 years and "1 dB is the accepted interference standard worldwide." The wrangling is set to continue through the rest of this year, but for now GPS is again under siege.

JAPAN MARITIME SELF-DEFENSE FORCE

COMMENTARY

Run Silent, Run Dumb

Australia's submarine project does not need added risk

By Bill Sweetman

Read Sweetman's posts on our blog **Ares**, *updated daily:*
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Next to combat aircraft, submarines are often the most expensive weapon programs in any nation's budget. They are also regional-strategic weapons in any conflict that has a maritime dimension, even if that is confined to a belligerent's need to import energy. The submarine's combination of stealth and persistence gives it a unique capability: It's a threat, even if it isn't there.

The U.S. Navy is even talking about a $3,000 air-dropped decoy that emulates a periscope—appearing, disappearing and moving slowly—and any submarine operator could develop something similar. Eric Frank Russell called this a "periboob" when he invented it for his 1957 sci-fi novel *Wasp*: "A periscope is a periscope; there's no swift way of telling the false from the real, and no captain in his right mind will invite a torpedo while trying to find out."

Australia's Sea 1000 project is one of the largest defense programs outside the nuclear powers, aiming to replace six Collins-class boats with 12 larger craft, which will be among the largest diesel-electric submarines (SSK) ever built. Unsurprisingly, it is also rapidly becoming politicized, with many observers concerned that Prime Minister Tony Abbott's government has already settled on a favored solution—to team up with two Japanese *zaibatsu*, Mitsubishi and Kawasaki, on a development of the Soryu-class submarine (see photo).

In a widely quoted statement in February, Abbott called the Soryu "the best conventional submarine in the world." The same description was used by Vice Adm. Robert Thomas, commander of the U.S. Navy's 7th Fleet, who was quoted last October as having told Australia's then-minister of defense: "You want to find the finest diesel-electric submarine made on the planet—it's made at Kobe works in Japan." Reuters reported in July that Britain's Babcock and BAE Systems were interested in joining the Soryu team.

A Japanese-Australian marriage with the U.S. Navy as matchmaker is politically attractive. All three parties are focused on the Pacific and China. The U.S. likes to see Japan more outward-looking as an alliance partner, and may be happier to see the General Dynamics BGY-1 combat control system and U.S. weapons—both Australian desires—on a Japanese-Australian SSK than on an alternative.

This trend is nevertheless unwelcome to Germany's ThyssenKrupp Marine Systems (TKMS) and France's DCNS, the world's leading exporters of SSKs and the alternative suppliers for Sea 1000. Also, it is not a low-risk solution to a risky project, following the major delays and overruns in the Collins-class program.

The risks begin with the way warships are built. The process usually starts with a proven hull design from a yard like TKMS or DCNS. The customer then selects a combat system, sensors and weapons; the contractor builds the first ships, but hull construction and assembly are brought in-country, creating a maintenance and overhaul base at the same time. With submarines, things get more complicated: Submarine construction uses specialized steel, many features are safety-critical and underwater craft are densely packed.

Japan has no experience of this process or of leading the design of an export warship. One Australian study cites this as an advantage (Soryu-based technology would be inaccessible to foreign navies), but most would call it a potential minefield.

Other aspects of a Soryu deal may have been oversold. Soryu is a large and capable SSK, but Sea 1000 calls for greater range, a vertical launch system for weapons (Tomahawk-class cruise missiles or the follow-on Offensive Anti-Surface Warfare weapon) and a large lock-out chamber for special forces: It will not be an off-the-shelf design.

Much has been made of the "next-generation" propulsion system apparently being developed for the forthcoming batch of Japanese navy Soryus, the 28SS class, which will apparently dispense with their Saab air-independent propulsion (AIP) systems and switch to lithium-ion (Li-ion) batteries.

Li-ion may be an alternative to AIP for Japan, which expects its submarine battle to be close to home waters. It permits faster silent running than AIP, which has lower maximum power output relative to volume—most AIP systems sustain low patrol speeds. But AIP stores more energy per unit of volume than Li-ion, and while some Australian studies still imply that AIP cannot be replenished at sea, the Swedes have demonstrated underway liquid oxygen transfer for their LOX-diesel Stirling-cycle system.

This is a good time for Australia's politicians to heed the advice of Will Rogers: "Never miss a chance to shut up." Sea 1000 needs a transparent, rule-based selection process; anything else is guaranteed to end in tears.

By Frank Morring, Jr.

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COMMENTARY

Growing Pains

'New Space' gets a few wrinkles as it matures

Elon Musk concedes the June 28 failure of a Falcon 9 launch vehicle with a load of supplies for the International Space Station (ISS) was a "huge blow" for SpaceX, the company he founded and which has come to epitomize the commercial "New Space" movement. Coming as it did on the heels of the Orbital ATK Antares explosion last October, also with a commercial load of ISS supplies, the SpaceX mishap raised more questions about the wisdom of trying to plant a new economic sector in low Earth orbit (LEO).

NASA/PLANETARY RESOURCES

The Obama administration's sharp push in that direction—built on the Commercial Orbital Transportation Services (COTS) seed-money effort started under President George W. Bush—shook up the traditional U.S. space industry, and SpaceX was a major beneficiary.

Former NASA Administrator Michael Griffin—who kicked off the COTS effort to get some contractor "skin in the game" of civil space transportation—estimates the government has spent "$3.5 billion, possibly more" with SpaceX since then. He told the House Armed Services Committee that kind of public spending was not in his original commercial space game plan, and now Musk says the launch failure will probably cost his company "hundreds of millions" in lost revenue.

The twin failures also were a blow to the commercial startups hitching rides to the ISS on the Orbital ATK Cygnus and SpaceX Dragon cargo vehicles. Planet Labs, which is developing a constellation of cubesat-sized spacecraft to deliver real-time Earth imagery from low Earth orbit, lost 26 of its "Dove" satellites on the Antares, and eight on the Dragon.

The Antares failure also took out the first spacecraft launched by Planetary Resources, a space mining startup planning to test avionics and flight control systems for future prospecting birds on its Arkyd 3 nanosat. NanoRacks, which pioneered commercial ISS payload accommodation, lost 51 customer experiments on the SpaceX, plus the eight Doves bound for its external nanosat dispenser.

NASA certainly wasn't expecting to lose both of its commercial cargo carriers—plus a Russian Progress freighter—in less than a year. But the U.S. agency and its Russian and Japanese partners still put three more crewmembers on the space station July 23, bringing it back to full strength. Progress seems back on track, and a big Japanese HTV vehicle is due in with supplies and research gear in August.

"We're still talking about research," says Mike Suffredini, NASA's ISS program manager. "We're not talking about modifying what we're doing on orbit."

Nor have the launch failures dampened momentum among the commercial companies that suffered losses. SpaceX and Orbital ATK both hope to return to flight this year (the latter on an Atlas V substitute while it re-engines Antares), and the startups that use their services are forging ahead.

Planetary Resources used the NanoRacks deployer to launch Arkyd 3 Reflight, a replacement for the lost testbed that was flown to the ISS on the SpaceX mission prior to the one that failed (see photo). Planet Labs has started deploying another "flock" of Doves also launched on that SpaceX 6 mission. And the company, with strong backing from the Silicon Valley venture capital community, continues its push to bring the planet down to everyone's laptop every day.

Earlier in July Planet Labs announced it will purchase BlackBridge, which owns and operates the five Canadian-built RapidEye spacecraft that have been providing 5-meter-resolution Earth imagery since 2009.

NanoRacks is also expanding. As it continues to develop new hardware for the ISS, including a commercial airlock (*AW&ST* March 16-29, p. 22), the company has teamed with Blue Origin to provide payload accommodation for scientific experiments and education projects on the New Shepard suborbital spaceflight vehicle.

When "Blue" begins flying its human-rated spacecraft as early as next year, NanoRacks will market space for payloads ranging from "a few ounces" up to 50 lb., as a way to repeat microgravity experiments quickly or raise the technology readiness level of new hardware with multiple flights. Virgin Galactic and XCOR Aerospace also hope to tap the suborbital research/education markets with vehicles they are developing.

The launch mishaps haven't slowed enthusiasm for commercial operations beyond LEO, either. As Planetary Resources was deploying its Arkyd space-prospector testbed, the International Academy of Astronautics was releasing a new study on space mineral resources as an economic engine for developing nations on Earth and New Space operators at the Moon and beyond.

"Once we are able to extract water and various minerals from the Moon and other heavenly bodies, it will have a tremendous synergistic impact on our ability to explore the Solar System and establish a true space economy," says George Nield, associate administrator for commercial space transportation at the FAA.

Edited by Jen DiMascio

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COMMENTARY

Real Intelligence

Scientists warn about the dangers of removing humans from weapons

An open letter opposing the marriage of machine autonomy and lethal weaponry has attracted more than 7,000 signatures from across the Artificial Intelligence (AI), information technology, aerospace and academic communities. It warns that taking humans out of the loop in weapons systems is "feasible within years, not decades," with potentially dire consequences. "If any major military power pushes ahead with AI weapon development, a global arms race is virtually inevitable, and the endpoint of this technological trajectory is obvious: Autonomous weapons will become the Kalashnikovs of tomorrow," states the letter, sponsored by the Future of Life Institute.

The signatories include physicists Stephen Hawking, Frank Wilczek and Lisa Randall; Tesla and SpaceX CEO Elon Musk; Apple co-founder Steve Wozniak; Skype co-founder Jaan Tallinn and Stuart Russell of the University of California-Berkeley, author of *Artificial Intelligence; a Modern Approach*. "Just as most chemists and biologists have no interest in building chemical or biological weapons, most AI researchers have no interest in building AI weapons—and do not want others to tarnish their field by doing so, potentially creating a major public backlash against AI that curtails its future societal benefits," the letter states.

GENERAL ATOMICS

Scientists want to make sure that future robotics operate like the MQ-9 Reaper, with a human in the loop.

OPTING OUT

Congress continued tussling over the Export-Import Bank but took a six-week recess without renewing the bank's charter, which expired at the end of June. On the way out the door, there were unusually harsh insults, plus threats and recriminations.

It started with Sen. Ted Cruz (R-Texas), a contender for the Republican presidential nomination. He accused Majority Leader Sen. Mitch McConnell (R-Ky.) of lying when the leader told Cruz there was no deal to include the measure to extend the export-credit agency's charter in a long-term highway bill. Then 64 senators wound up supporting Ex-Im bank extension, and an amendment was attached to the bill. It was the kind of comment that drew a collective wince from other senators.

But the House left town without approving the Senate's highway measure, leaving the bank in limbo. And that had Boeing Chairman Jim McNerney making threats of his own to pull manufacturing operations out of the U.S. (see page 12). With the presidential campaign season picking up steam, efforts to overturn Obamacare and other obstacles threaten to slow passage of almost any legislation. The bank has operating funding through September.

THE MISSILE EAST

With Congress yet to approve the newly achieved Iran nuclear agreement, the State Department is recommending that Congress approve a round of weapon sales to the Middle East. The whopper is a deal with Saudi Arabia for 600 Patriot missiles worth $5.4 billion. Other deals include $500 million worth of ammunition for Saudi Arabia and a $335 million package for the AN/AAQ 24(V) directional infrared countermeasures system to the United Arab Emirates.

The deal for Raytheon's missile defense system includes related equipment. The Defense Security Cooperation Agency avers that the sale would not alter the "basic military balance" in the region. "The proposed sale will modernize and replenish Saudi Arabia's current Patriot missile stockpile, which is becoming obsolete," says a notice from the agency. "The purchase of the PAC-3 missiles will support current and future defense missions and promote stability within the region." Like the Iran deal, the sales must still be approved by Congress.

DEEPENING TIES

A top U.K. defense minister met with key Pentagon officials July 28 and discussed a number of matters, including the F-35 and nuclear submarines. "I came as the first British defense minister since the new government took over," Phillip Dunne said. "I came specifically to invite U.S. participation and views on our strategic defense and security review (SDSR)." As a result, the SDSR is likely to include a section on the U.K.-U.S. relationship.

In addition to talking with Deputy Defense Secretary Robert O. Work and the Pentagon's head acquisition official, Frank Kendall, about how the U.S. and U.K. could strengthen their already solid collaboration via the upcoming review, the trio also discussed F-35 sustainment. In a speech in Washington before The Cohen Group—a consulting and lobbying firm run by former U.S. Defense Secretary William Cohen—Dunne repeatedly highlighted the strength of the U.K.'s industrial base. He added that he hopes the U.K. will play a role in sustaining European F-35 fleets. And he reiterated in a gentle but firm way that the U.K. buys "rather more" from the U.S. than the other way around.

Staking a Claim

As a strategic move, U.S. airlines are buying shares in carriers in key markets

Delta plans to spend $450 million for a 3.5% stake in China Eastern Airlines.

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Brian Sumers Los Angeles, Kristin Majcher Boston and Bradley Perrett Beijing

Flush with record profits and having already committed billions of dollars to improving their own businesses, U.S. airlines are increasingly looking abroad for investment opportunities to strengthen their standing in key global markets. But while most of these moves look prudent, there is no guarantee they will be successful, especially given the rocky history of many airline investments.

The investments are tricky because U.S. airlines generally have little control over their foreign counterparts. There are some exceptions—Delta Air Lines owns 49% of Virgin Atlantic, and because the two have antitrust immunity they can coordinate operations—but in most cases, airlines are buying small interests, sometimes without a board seat.

Delta and United Airlines have each made big splashes recently by buying stakes in carriers in developing markets—Delta with China Eastern and United with Brazil's Azul Airlines. But the investments are tiny. Delta is paying $450 million for a 3.5% stake, while United will invest $100 million for 5%. This entitles Delta to an "observing" seat on China Eastern's board; United will have a traditional seat.

Post-merger United is new to these types of investments, but this approach has been part of Delta's strategy for several years. In 2011, Delta invested $65 million to secure a 4.17% stake in Aeromexico and $100 million for a 3% piece of Brazil's GOL Linhas Aereas. Earlier this year, Delta said it will increase its stake in GOL to 9%.

Why are Delta and United using this strategy?

Both carriers undoubtedly hope to turn a profit by selling their stakes someday. But several analysts note that long-term strategic interests seem to be the ultimate goal. For example, Delta wants to be a major player in Europe, China and Brazil, and it likely calculated it would have a better chance

PRIZED PARTNER

Adrian Schofield Auckland

Delta Air Lines is looking to strengthen its position in the Japanese market by entering the battle over the future of local carrier Skymark Airlines. It faces stiff competition, however, as All Nippon Airways (ANA) is also aiming to invest in Skymark as part of a rival bailout plan.

It may seem odd that airlines would covet a carrier in bankruptcy protection due to a failed business model. But Skymark has value because of its domestic network centered on Tokyo's Haneda Airport, where slots are in high demand by Japanese and foreign airlines. Delta could potentially link with Skymark at Haneda and offset the advantage its U.S. competitors enjoy through their alliances with Japan's two major carriers.

Two rival coalitions are offering to invest in Skymark and help it return to financial health. The carrier entered bankruptcy protection in January, with investment company Integral Corp. agreeing to become debtor-in-possession. Integral has submitted a rehabilitation plan involving ANA and leading Japanese banks.

However, Skymark's major creditor—aircraft lessor Intrepid Aviation—was not happy with that plan, mainly due to ANA's involvement. Intrepid has been working to assemble a competing plan, and recently confirmed that Delta would be a member of its team.

A Japanese court has approved both proposals, and Skymark's creditors will vote on them at an Aug. 5 meeting. Intrepid must secure the support of other creditors—particularly Airbus and Rolls-Royce—to gain acceptance for its plan.

Under Intrepid's rehabilitation scenario, Delta would likely have a stake of less than 20% in Skymark. The two airlines would also presumably form operational links, including code-sharing.

While Delta has more service to Japan than any other U.S. airline, American Airlines and United Airlines benefit from joint ventures with Japan Airlines (JAL) and ANA, respectively. These arrangements,

if it owns a portion of powerful airlines there. United, presumably, wants more relevancy in South America, where it is historically weak. On the carrier's second-quarter earnings conference call, CFO John Rainey said the deal "... will strengthen our Latin network and provide United's customers with exclusive connection opportunities throughout Brazil."

Closer collaboration is important. In the past, airlines worked together by negotiating traditional code-share agreements. They also joined the same alliances. But those relationships are becoming increasingly frayed, with many airlines instead preferring to work with carriers with which they share a strong fiscal bond. A simple codeshare is not enough anymore.

"This is the next step beyond global alliances now," analyst Mike Boyd says. "Right now the close relationships are going to be the ones that have a financial tie to each other."

Often airlines have preferred immunized joint ventures over investments. But those relationships are not always possible, since an open skies agreement between the U.S. and a carrier's home country is a prerequisite for antitrust immunity. If the U.S. eventually reaches an open skies deal with China, presumably Delta will be the preferred joint venture partner for China Eastern. This is essentially what happened with Delta and Aeromexico. Delta bought its piece before the U.S. and Mexico liberalized their air service treaty, and now the two airlines seek to form an immunized joint venture.

In the short term, Delta's investment in China Eastern, if approved by the airlines' boards, will allow the carriers to jointly invest in technologies and products and provide a seamless booking experience for travelers flying on both carriers, Vinay Dube, Delta's senior vice president-Asia-Pacific, said in a posting on the carrier's website. The airlines say the partnership can help them be more competitive on U.S.-China routes.

Foreign companies that help Chinese companies, especially state enterprises, can sometimes expect favorable treatment from the government, conceivably an important advantage in so political an industry. But it seems doubtful Delta's contribution to China Eastern is big enough to budge the needle in Beijing, one analyst infers. (Some insiders have noted that even while Delta is investing in one airline with strong ties to the national government, it continues to criticize the three largest Middle Eastern carriers, accusing Emirates, Etihad Airways and Qatar Airways of taking government subsidies.)

Delta's investment is small compared with the cross shareholdings of Air China and Hong Kong's Cathay Pacific. Air China owns 30% of shares in Cathay, which owns 18% of Air China. And that deeper equity connection, announced nine years ago amid great expectations, has resulted in only a distant relationship (*AW&ST* March 10, p. 43). Delta will gain negligible influence in running China Eastern, so a Chinese industry analyst suggests that the U.S.-based airline's main motivation must be simply the prospective returns on an equity investment.

Analyst George Hamlin says he is skeptical Delta or any other U.S. airline needs to invest in a foreign carrier in order to curry a close relationship. "In theory, that might make your partner less likely to bolt and choose someone else or go on their own," he says. "But in practical terms, when you have below 10%, what are you going to prevent, especially when it's non-voting?"

It is a little early to tell whether these investments are the beginning of a long-term trend, or if this is just a couple of airlines using cash for one-time opportunities. But as long as U.S. airlines continue to make money, they'll have to figure out what to do with their profits, and investing in other carriers could be part of the solution.

In the second quarter, American Airlines reported $1.7 billion in net income, while Delta reported $1.49 billion and United $1.19 billion. Other U.S. airlines also reported big gains, though they're far less likely to take a stake in global carriers. Southwest Airlines made $608 million, Alaska Airlines earned $234 million and JetBlue Airways took in $152 million.

—With research by Ryan Wang

protected by antitrust immunity, allow the partners to cooperate in the U.S.-Japan market and give them access to Japanese domestic networks.

Delta has long sought a Japanese partner, and a Skymark link would give Delta a boost in this market. But the advantage would be much smaller than the transpacific joint ventures.

Skymark has only domestic services, and its network has shrunk since the bankruptcy filing. Another limitation on a potential partnership is that almost all of Delta's Tokyo flights are to Narita Airport, with only two routes to Haneda from Los Angeles and Seattle. And Delta has to relinquish the Seattle slot later this year because it is not used frequently enough.

The opposing bailout plan has formidable support. Under that proposal, Integral would hold a 50.1% ownership share in Skymark, ANA would hold 16.5%, and the remaining 33.4% would be owned by a fund jointly created by the Development Bank of Japan and Sumitomo Mitsui Banking Corp. These partners have agreed to invest a combined ¥18 billion ($145.2 million) in Skymark.

For ANA, Skymark's slot holding at Haneda has considerable appeal. After a round of new international slot awards last year, Haneda is essentially full, so code-sharing with Skymark is one of the few ways ANA could continue to grow its operations there. Details of prospective links between the two carriers' networks have not been revealed, but this would be a feature of ANA's involvement.

One of the factors behind Skymark's failure was its acquisition of widebody aircraft to complement its predominantly narrowbody fleet. The termination of order and lease agreements for the widebodies has remained a major issue in the negotiations over rehabilitation plans.

Skymark had six Airbus A330s, mostly leased from Intrepid, and ceased flying them as soon as it filed for bankruptcy protection. Intrepid held discussions with ANA about the possibility of that airline taking over the A330 leases, but ANA opted against such a move. This appears to have been a major factor in Intrepid's decision to seek a different airline partner for Skymark.

Skymark also owes hefty penalty fees to Airbus due to the termination of orders for six A380s last July.

Numbers Game

New standard rules cut jetliner family generic range, but actual performance unaltered, says Boeing

Guy Norris Los Angeles

Over the Aug. 1-2 weekend, generic range performance and in some cases seating capacity of Boeing's airliner family, as advertised on the company's website, mysteriously changed. The range of the single-aisle 737 family will decrease by 115-645 nm while the ranges of the widebody 777, 777X, 787 and 747-8 families will decline by an average of 520 nm.

So what is happening? Has Boeing unearthed a drastic performance shortfall across its product range, or has it discovered a hitherto undiagnosed design problem?

The answer, it turns out, is more prosaic. After more than 20 years of using the same standard rules to determine the seating arrangement and baseline range of its product line, the company is revising these parameters to mirror fundamental shifts in customer behavior, and the growing weight of its passengers and their seats.

"We decided to update the generic seat count and performance information in our brochures," says Boeing Commercial Airplanes Marketing Vice President Randy Tinseth. "The main reason is that the configurations we use were developed in the 1990s. Since then, business class has evolved and airlines have gone more [often] from three to two classes, especially for long-range. We wanted to make sure our ground rules better reflect the way customers are using them," he adds. "Business class seats are also more complex and heavier than when we first did the rules." In addition, the average passenger and his bags weigh more than they did 20 years ago.

While Boeing declined to specify the assumed weights it uses, for competitive reasons, it says the updated standard rule for passenger/luggage weight is now 15 lb. higher, which is "more in line with what customers are currently using," it adds.

"These changes reflect both the heavier weight of seats, particularly the business class seats that weigh up to 100 lb. more, with all the furniture around them and the lie-flat features, and the fact that more operators are moving away from first class," says James Haas, director of product marketing. "We looked at all the delivered 787 aircraft and found that 90% of them do not have first class. Instead they have business and economy, or business, premium economy and economy."

While fewer classes means additional seating space, the weight increase inevitably affects the generic range capability of the overall product range. However, since the actual range/payload of specific models is not changing for individual operators—who already factor in increased weight and seating—Boeing is clear that the changes in the generic performance data do not mean a reduction in baseline performance. "People wonder if we are trying to mask performance changes. The answer is no," says Haas. "The bottom line is seat counts are changing, and on average for the twin-aisles we are seeing around a 10-seat increase. But since the aircraft are heavier, then it looks like range is 500-600 nm less. This could be misinterpreted as 'performance is going down.' In fact everyone's range [including Airbus and Boeing] is going down. So the advantage we have in range [over Airbus], we still have. The delta doesn't change."

"We show performance in terms of specific rules, and now we have more recognizable rules that make sense," says Tinseth. "The aircraft itself is unchanged, what has changed is just the way we present generic range and payload. We haven't made changes in what is offerable [in terms of product] and the performance guarantees do not change."

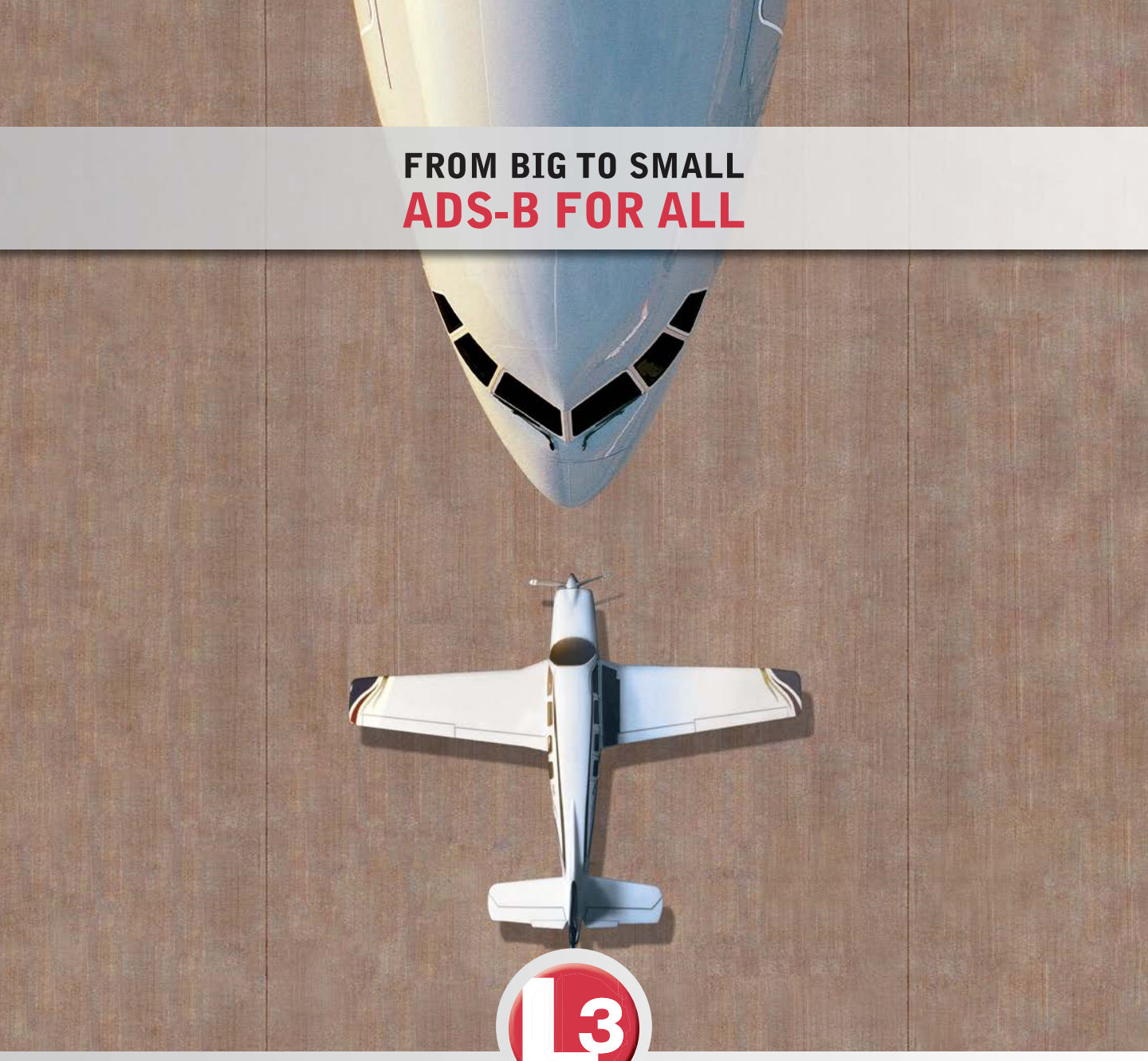
Boeing Airliner Ranges and Payloads:
Before and After Standard Rules Change

	Seats			Range	
Aircraft	Current Standard 2-Class	Current Standard 3-Class	Prior	Current	Prior
737-700	126	N/A	126	3,010 nm	3,445 nm
737-800	162	N/A	162	2,935 nm	3,085 nm
737-900*	178	N/A	180	2,950 nm	3,050 nm
737 MAX 7	126	N/A	126	3,350 nm	3,850 nm
737 MAX 8	162	N/A	162	3,515 nm	3,660 nm
737 MAX 9*	178	N/A	180	3,515 nm	3,630 nm
737 MAX 200	200**	N/A	200	2,700 nm	3,345 nm
787-8	242	N/A	242	7,355 nm	7,850 nm
787-9	290	N/A	280	7,635 nm	8,300 nm
787-10	330	N/A	323	6,430 nm	7,000 nm
777-8X	350-375	N/A	350	8,700 nm	9,300 nm
777-300ER	396	336	386	7,370 nm	7,850 nm
777-9X	400-425	N/A	400	7,600 nm	8,200 nm
747-8	N/A	410	467	7,730 nm	7,790 nm

*737-900 and 737-9 with one optional auxiliary tank
**One-class configuration

Source: Boeing

FROM BIG TO SMALL
ADS-B FOR ALL



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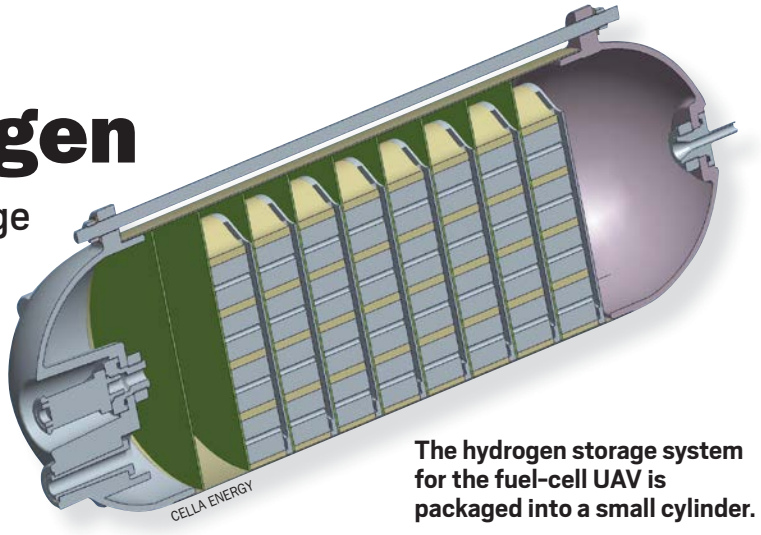
Solid Hydrogen

Solid-state hydrogen storage could dramatically improve small-UAV performance

Graham Warwick Washington



The hydrogen storage system for the fuel-cell UAV is packaged into a small cylinder.

Battery life is a major limitation on the operation of small electric-powered UAVs. Several manufacturers have shown hydrogen fuel cells can significantly extend endurance, but the idea has not caught on because of weight, safety and logistics drawbacks.

Now U.K. company Cella Energy is to study the feasibility of applying its solid-hydrogen fuel system to a fuel-cell power unit for Israel Aerospace Industries' (IAI) BirdEye mini-UAV. The study by Cella and IAI is funded by Space Florida and Israel's Industry Center for Research and Development.

Cella was spun out from the Rutherford Appleton Laboratory in Chilton, England, as a result of a project to improve hydrogen storage using nanotechnology, says managing director Stephen Bennington. The team worked on materials identified by the U.S. Energy Department, including ammonia borane, a rocket fuel from the 1950s.

"This has an enormous amount of hydrogen in it, which comes out relatively fast at a relatively low temperature, above 100C," he says. "But it melts, creating a foaming mess, and is impossible to use." Using nanostructuring, the team developed a solid compound that worked well as a means of storing hydrogen. One gram of the material can store about 1 liter (0.3 gal.) of hydrogen gas.

"We spun out in 2011, and thought 'that's it.' But nobody is interested in hydrogen, they want energy. So we began work on a power system at different scales, from a few hundred Watts for UAVs to larger scale for aerospace and automotive," Bennington says.

Cella's material comes in the form of pellets, which look like beads of white plastic, mounted on a printed circuit board. Heaters on the board warm each pellet in sequence, driving out the hydrogen, which is run through a filter to clean it then fed to the fuel cell.

"It is almost a drop-in replacement for batteries. At sufficient scale, it has three times the energy storage of a lithium-ion battery and will give a micro-UAV three times the range," he says. "Unmanned aircraft is a nice market, as they are desperate for range and willing to pay a premium for it."

With funding from the U.K. government, Cella has collaborated with the Scottish Association for Marine Science (SAMS) to use its hydrogen storage in a fuel-cell-powered UAV. Initially the system was integrated into the wing of a UAV. "It worked okay, but the aircraft was too small," he says.

The system works better at bigger sizes, and Cella will fly a third prototype with SAMS in late August. It will use a cylinder 100 mm in diameter and 300 mm long that stores 0.5 kWh of energy. "We are showing a significant improvement over lithium-ion batteries in weight performance," Bennington says. "In the SAMS demo we are getting more than two times the specific energy of lithium-ion batteries, and see the scope for improvement to three times."

The power system is being used in the IAI study, which will run to April 2016 and result in a fuel-cell power system design for BirdEye. "After April we hope to fly in the real system, then streamline the design for production," he says.

The complete power system comprises the solid-hydrogen gas generator, control board, fuel cell and a battery to provide peak power for short periods, for takeoff and maneuvering. The gas generator will plug in, and when exhausted will be replaced and returned to Cella in exchange for a new unit.

Bennington says the advantage of Cella's approach over other methods of fuel-cell hydrogen storage is that it is solid state, with no moving parts. The system runs at low gas pressure compared with compressed hydrogen storage, which requires heavy, high-pressure bottles that have to be refilled.

Compared with lithium-ion batteries there is no risk of high-temperature metal fires that are near-impossible to extinguish. "It is not sensitive to air, or bare skin. If the containment is breached, nothing happens. Before use there is nothing toxic, and after use only a tiny bit of hydrogen is in there," he says. This would make them safer to transport by air than batteries.

Cella has been working with Safran about a year on large-scale fuel-cell power systems for aircraft. "We are looking at systems in the 2-10 kW range, using pellets that are very big—rods that are a few centimeters in diameter and tens of centimeters long. You heat up one end and get an enormous amount of hydrogen out," Bennington says.

"We have a system working on our bench," he adds. "Safran is funding development because aerospace compliance is tough. We will scale up again to something much larger, and in five years fly something."

One challenge is driving down the cost of the storage material, which is why the UAV sector, with its willingness to pay for endurance, is an attractive first market. Cella is looking at automotive use, but this will require much lower cost than either UAVs or aerospace.

"The cost is in the material. The elements are dirt cheap—boron and nitrogen are hugely abundant—but we put a lot of energy into it and that is expensive," he says. For the larger aerospace and automotive markets, Cella is looking at regeneration technology, but for now that is at low maturity.

Two automotive applications are being developed with government funding from Innovate U.K. One, a range extender for electric cars, would provide 100-200 km (60-120 mi.), then be swapped out at a filling station. The other involves injecting 5-10% hydrogen into diesel to clean up particulate emissions.

Rising Stakes

Four teams could be in the running

Bill Sweetman Washington, Bradley Perrett Beijing and Amy Butler St. Louis

As the U.S. Air Force refines its requirements for T-X, formally known as the Advanced Pilot Training Family of Systems program, competition is intensifying, with competitors and other observers noting that the service is looking for a capable, high-performance aircraft to prepare pilots for the F-35 Joint Strike Fighter.

Korea Aerospace Industries (KAI) is studying a further package of improvements for the T-50 Golden Eagle, offered for USAF together with Lockheed Martin, while Alenia Aermacchi is still in talks with a new U.S. partner, telling Aviation Week that a deal should be announced "very soon."

Meanwhile, Boeing and Saab could fly their T-X advanced trainer demonstrator before the end of the year, says Debbie Rub, Boeing vice-president for global strike. She said on July 28 that the company's T-X demonstrator is close to its first flight. "Can I say we will fly next year?" she asked, glancing at public relations officials during the question-and-answer session of a briefing on strike programs in St. Charles, Missouri. "We will fly this year or we will fly the year after," she added. "We want to win. We have a partnership with a great company, Saab, [and] we will do what it takes to win."

Boeing and Saab have moved quickly, having announced their teaming agreement less than two years ago. Northrop Grumman CEO Wes Bush told financial analysts on July 29 that the company would be unveiling its new clean-sheet demonstrator, built by its Scaled Composites subsidiary, "in the coming months."

In recent clarifications to the request for information (RFI) originally released in March, the Air Force says that a flight demonstration may be required as part of the source-selection process. In the case of Boeing-Saab and Northrop Grumman, the demonstrator need not be a production-standard aircraft but should be "highly relevant to the production configuration."

Alenia Aermacchi's T-100 proposal, based on the M-346, has been in limbo since its original partner, General Dynamics (GD), backed out in March, and it is not disclosing the identity of its potential teammate. A leading possibility is Textron, the only U.S. builder of jet aircraft, aside from GD, that is not already committed to T-X. It has become a more likely T-X partner since Alenia Aermacchi's former link with GD dissolved. Meanwhile Textron has moved into the fixed-wing military business, acquiring Beechcraft and the T-6 program and launching the Scorpion reconnaissance and attack aircraft. Asked whether it is in talks with Alenia Aermacchi, the company says only: "It is Textron's policy not to comment on market rumors."

A key to Alenia Aermacchi's revived proposal is that the Air Force, in a July 10 amendment, clarified the sustained g-performance requirement contained in the initial RFI, which seemed to eliminate the M-346. Rather than the common definition of sustained g-force as being achieved at constant speed and altitude, the T-X requirement is to perform a specific maneuver, designed to evaluate and improve the student pilot's performance at high g, in which 6.5g or more is sustained through a 140-deg. turn.

The RFI states that the maneuver must start at or above 15,000 ft. and end no lower than 13,000 ft. while the aircraft loses no more than 10% of its initial speed. The maneuver has to begin with at least 80% internal fuel, so that it can be performed at any time during a training sortie.

The M-346 is compliant with this requirement but "on the line," says company chief test pilot Enrico Scarabotto, and Alenia Aermacchi is planning to increase its performance before any T-X flight demonstration takes place. He adds that the RFI requirement as originally interpreted would be hard for any aircraft short of a fighter to achieve, and that the M-346 has proven itself to handle well at such g levels, with minimal buffet. "That allows the pilot to concentrate on the g-straining maneuver, rather than fighting the aircraft to hold 6.5g." The specified maneuver "is extremely dynamic."

Having passed the sustained-g hurdle, Alenia Aermacchi is positioning the M-346 as the most modern in-service training system in the contest, with features such as live, virtual, constructive (LVC) training (in which a real-world training sortie can be combined with simulated adversaries, targets and allied assets) already in development.

Alenia Aermacchi is exploring aggressor applications for the M-346; the aircraft has flown such missions with Italian air force Typhoons.

ALENIA AERMACCHI

The Italian air force has an initial-service version of LVC; the full version will be delivered next year, the company says. The training tool has already been used to allow the M-346 to simulate beyond-visual-range adversaries while acting as an aggressor for the air force's Typhoon fighters. The M-346 is equipped with the Elbit Targo helmet-mounted display (HMD), which can be installed in both front and rear cockpits and can be used in LVC to provide what the company calls "dome in the air" experience, with simulated targets projected onto the visor.

Engineers working on LVC infrastructure technology at Rockwell Collins's Advanced Technology Center in Cedar Rapids, Iowa, confirm that the Air Force is asking more rather than less from the T-X as the process of defining requirements continues. "In the last couple of months," says LVC strategy leader Chip Gilkison, the customer has started to see a need for the T-X to act as a lead-in fighter trainer for the F-35, as more pilots join the new program. "They have recently started taking pilots from the T-38, directly to the F-35. Previously they would go from the T-38 to the

F-16 and then to the F-35." A combination of LVC and high-performance companion trainers, Gilkison says, is needed to train pilots to the full potential of the F-35's sensor suite.

Meanwhile, South Korea's trade and industry ministry is launching development of key improvements to the T-50—including inflight refueling and software—offering contracts that cover about 60% of their cost. The ministry does not mention the competition as the reason for upgrading the T-50, but the purpose is clear, since the defense ministry is not paying for the work and because the South Korean air force is not known to have asked for these improvements. However, the changes could make the T-50 more appealing to other export customers.

The T-X requirement calls for the ability to refuel from a boom-equipped tanker—not provided on any previous trainer and missing from both the M-346 and T-50. The South Ko-

Fuel Charge

Boeing's charges to keep KC-46 afloat total $1.2 billion

Amy Butler Washington

The latest charge against Boeing's KC-46 aerial refueler program arose from overly optimistic certification planning, and from critical parts falling short of design specifications. This time, the $835 million pretax charge will pay for redesigns and retrofits required to address a faulty integrated fuel system, the heart of an aerial refueler.

At least some of these defective parts came from suppliers, while other integration shortcomings are Boeing's. Managing supplier quality is a familiar conundrum for the company, one that contributed to billions of dollars in overruns for its 787 airliner development.

In the case of the KC-46, and "in preparing for and performing [fuel system qualification] testing, we identified a number of fuel system parts and components that did not meet specifications and needed to be redesigned," says a Boeing spokeswoman, noting poor designs were found in pumps, valves, couplers and other equipment. "We're adding [the] resources [engineers and ancillary staff] needed to support the engineering redesign, manufacturing retrofit and qualification and certification of the fuel system changes, and the conclusion of functional and flight testing." The fuel system powers the KC-46 and funnels gas to receiver aircraft, which tank up from a centerline boom or wing-mounted pods.

When the company won the program in 2011, CEO Dennis Muilenburg, then head of the defense division, touted a "one Boeing" approach that would combine expertise and lessons from both the defense and commercial sides to mitigate risk for KC-46. These latest issues—along with last year's wiring problems—call the initiative's efficacy into question.

The recent charge brings Boeing's total pretax overrun to $1.26 billion since it won the contract over Airbus, then called EADS, in 2011. The U.S. Air Force's fixed-price contract, with a ceiling of $4.9 billion, is paying off. Had this been a cost-plus contract, the government would be responsible for a roughly 24% overrun, well into the dreaded territory covered by the Nunn-McCurdy program oversight law that triggers a series of reviews to validate a program once it breaches its estimates, at 25%.

Boeing's after-tax charge is $536 million. The lion's share—$513 million pretax—comes from Boeing Commercial Airplanes, which is providing the 767 baseline platform, while Boeing Military Aircraft, a division of Boeing Defense Space and Security, is paying $322 million pretax.

"The increased company investment on that program is driven primarily by required rework on the integrated fuel system, [which] was identified as we prepared for and conducted ground and flight test and verification of that system during the second quarter," said Muilenburg in a July 22 earnings teleconference. "No new technology is needed to resolve this issue, which is well-defined and understood. But that in no way mitigates our disappointment in having to take this charge."

Multiple Boeing spokesmen declined to say when the test problems came to light, beyond pointing to the second quarter, or April-June. And they would not address when the problems were revealed to the company's top leadership.

Boeing officials showed off their new refueling boom design during a fit check in the midst of a media tour; the boom was not able to pass fuel, however.

On May 26, then-Boeing CEO Jim McNerney (who now serves as chairman) told Aviation Week the program appeared on track. "If there were any cost overruns [anticipated] we would tell you. Could things go wrong? A test [anomaly] that would cause a delay or an extra charge? It's a possibility. But it's not what we see today. We have a high degree of confidence," he said.

Asked about the timing during the July 22 call, McNerney said, "In that specific interview you are talking about, I never made a categorical statement. I said we are always reviewing it and when we see issues we deal with them. The fact was that in the second quarter, as we went about fuel system and flight test we began to see issues that you only see when you integrate a fuel system into an airplane."

Once it won the fixed-price contract, Boeing began investing in five system integration laboratories (SIL), a key risk-reduction strategy, according to Maureen Dougherty, program manager at the time they broke ground. Though the SIL burned the project's management reserve at a higher rate than planned, company officials said they would pay off long- term.

Among the five is a wet-fuels lab, designed to replicate the jet's entire

rean government program calls for a single dorsal-mounted unit combining a refueling receptacle and a 600-lb. fuel tank, apparently in order to minimize redesign of the structure or loss of fuel capacity to the receptacle. The target development cost is 6.9 billion won ($5.94 million), of which the government will pay $3.6 million. The project is expected to run from August 2015 to July 2018.

The separate avionics work will support a large cockpit display, an HMD, an improved head-up display (HUD) and embedded training system for a trainer aircraft. The industry ministry is seeking bids for the 7.95 billion won project, with the government paying $4 million.

One of the main goals is to simulate the high-off-boresight air-to-air missiles. Beyond fuel and software, the industry ministry is calling for work on the T-50's air data system and is seeking a carbon-fiber leading edge for the fin.

BOEING/JOHN D. PARKER

fuel system, including the boom. Muilenburg suggested at least some of the problems were discovered in the SIL. "We invested in a system integration lab that allows us to find some of these issues now, rather than later in flight test," he says.

However, program concurrency, acknowledged as a manageable risk when the company won the contract in 2011, is growing. As officials devise and test fixes, the first two production birds, known as EMD-1 and EMD-2 are already loaded onto the production line in Everett, Washington, Muilenburg says.

"[Boeing is] working through the qualification process of the complete KC-46 weapon system, and not surprisingly the integrated fuel system is a large part of that effort," said Brig. Gen. Duke Richardson, program executive officer of tankers for the Air Force. "With EMD-1 exiting fuel dock and preparing to return to flight and the entry of EMD-2 into fuel dock, Boeing continues to make solid progress. While we have more heavy lifting coming up, we believe it is achievable and do not see any technical showstoppers." These are two of the four developmental test jets in the program.

Boeing's build model for the KC-46 is to fabricate the wiring and plumbing needed for the tanker on the commercial manufacturing line, producing what they are calling the 767-2C baseline. Once off that line, the -2C is outfitted with additional mission systems, such as the wing refueling pods, boom and defensive systems, to become a KC-46.

This production and development concurrency is leading to retrofits for early jets, accounting for at least part of the new cost increase.

The charge comes just as Boeing has announced its largest-ever 767 sale: FedEx has agreed to buy 50 767-300F freighters, with options for another 50. And China's largest freight operator, SF Express, is expected to place an order for 30 767-300Fs later this year. The production line is now ramping up to a rate of two per month—up from 1.5—Muilenburg says.

But this is the second charge Boeing has taken on a tanker within the last year. The company took a $272 million after-tax charge—$425 million pretax—last summer due to an inadequate design for wiring bundles on the aircraft. The Air Force requires redundancies and "safe separation" between some wiring components in the militarized 767, and the design fell short. This resulted in an extensive redesign and a months-long delay to the tanker's first flight, now hoped for in September.

Muilenburg says the company is "investing the necessary resources" to deliver the first 18 KC-46s by August 2017, as required in the contract. "We have our arms around this," he says. "We understand the work that has to be done."

However, each delay at this phase shaves off available time to address any possible flight-testing discoveries. When the contract was announced, the Air Force and Boeing touted a new, integrated approach toward certification and testing that would maximize the efficiency of each flight in satisfying test points for each purpose. This was already a risky approach, and is now made more challenging.

Boeing's philosophy on KC-46 has been that it will recoup any losses in development with U.S. and, eventually, foreign sales. During the call, McNerney predicted a market for 400 tankers, representing $80 billion in sales.

However, the company has yet to score a foreign sale. It recently lost its campaign to sell the tanker to South Korea, which opted for an Airbus A330 design—as have eight other nations.

Since winning the contract, Boeing has contended that government estimates for KC-46's completion, predicting overruns, were pessimistic. "Boeing's announcement is consistent with [Defense Department] expectations that the KC-46 tanker program would overrun the bid price in development," Pentagon procurement chief Frank Kendall tells Aviation Week. "The department has every expectation that Boeing will fulfill its contractual obligations."

Following last year's charge, Kendall predicted more overruns, to the company's chagrin. "Boeing has taken a pretty large loss that they recently booked against the tanker. We expected that. There's potential for additional loss that Boeing would have to absorb," he told Aviation Week last November.

Last year, the Air Force's KC-46 program office increased its estimate for completion by $441 million, to $6.3 billion. A Boeing spokeswoman said last December that the company's estimate to finish development was far lower, but she did not provide a number.

However, the $4.9 billion ceiling paid for by the government, coupled with the $1.26 billion charge brings the current cost of $6.16 billion close to the government's estimate.

In 2011, Boeing's bid price for developing and delivering 179 KC-46s was $20.6 billion, a full 10% lower than Airbus's. The Europeans offered the A330 tanker—which has consistently bested KC-46 internationally—at $22.6 billion, said Ralph Crosby, the losing company's chairman in 2011. Boeing could have bid a far higher price—avoiding these charges—and still won the duel.

Instead, Boeing won the program by aggressively underbidding Airbus, to prevent the European rival from getting a government-funded manufacturing foothold stateside.

The first 767-2C, the modified commercial variant upon which the KC-46 will be built, took its first flight Dec. 27.

"[Boeing is] working through the qualification process of the complete KC-46 weapon system, and not surprisingly the integrated fuel system is a large part of that effort," he says.

Prior to the revelations about the integrated fuel system shortfalls, Richardson said the start of production was already expected to slip by as much as six months. It is unclear when production will begin, putting further pressure on Boeing's delivery goal.

"We remain optimistic Boeing will meet the required assets-available target of 18 operationally ready KC-46s by August 2017," Richardson says. "Boeing continues to meet their commitments on this program at no additional cost to the government."

Meet the Fokkers

TONY OSBORNE/AW&ST

With Fokker buy, GKN positions itself on new platforms

Tony Osborne London

With a recent spate of acquisitions, British aerostructures firm GKN Aerospace is positioning itself as one of the key suppliers for the industry giants.

The purchase in June of California-based Sheets Manufacturing Co. (SMC) allowed GKN to secure major contracts from Boeing for the 737 MAX and 777X programs. And now the addition of Dutch aerostructures company Fokker Technologies opens the door to additional work on the Airbus A350 and the F-35 Joint Strike Fighter.

The €706 million ($779 million) acquisition from Arle Capital Partners—signed July 28—also includes Fokker's 5.5% share in the NHIndustries consortium with Airbus Helicopters and AgustaWestland to produce the NH90 military utility helicopter.

The takeover is the latest chapter in the long-running saga of Fokker, a brand dating back to flight's earliest days. In the 1980s it was one of the largest manufacturers of regional airliners, but it became insolvent during the '90s when the regional airliner market shifted in favor of competitors in Brazil and Canada. Today, the aircraft component manufacturer and MRO provider employs 5,000 and remains the Netherlands' aerospace champion despite its troubled past.

GKN believes the purchase will position it as the global number two in aerostructures, behind Spirit AeroSystems, and number three in electrical systems—an area new to it that it has had a close eye on for some time—behind Safran and Latecoere.

"Fokker ticks all the boxes on GKN's strategy," CEO Nigel Stein told investors in London "[It is a] great fit, with attractive financials, and is a quality company that will add to [our] capability."

GKN's board has focused on aviation as its top priority in recent years, beginning with its first major gamble—the takeover of Volvo Aero in 2012—which has placed the company in a strong position on a number of new engine programs.

GKN foresees only limited growth in propulsion and is concentrating instead on airframe capabilities, targeting workshare Boeing commercial products in particular. The takeover of SMC—a privately owned metallic spin forming company—gave it quick insight into the production of aircraft engine inlet lip skins, earning it work on Boeing's newest programs. Fokker's main experience is in fuselages, empennages and wing components. It also has a significant presence in business jets, an admitted area of weakness for GKN, despite success earlier this year in winning wingskin work from Gulfstream for the G500 and G600 jets.

Fokker may not build regional aircraft anymore, but its services division looks after much of the world's remaining fleet.

"[We are] firmly onto Boeing's growth platforms," says Stein. "Our aerospace business is positioned for future growth . . . [and] well-positioned to outperform our global markets."

GKN currently produces the canopy and some titanium structures for the F-35. With Fokker's involvement, it will add flaperons, doors, arresting gear and wiring systems to its workshare. On the A350, Fokker adds the composite outboard flaps to GKN's work on the wing spars, windows and trailing edge parts.

In 2014, the Dutch company generated revenues of €758 million. Much of this came from the aerostructures business, but some was in the electrical systems business of Fokker Elmo, in landing gear work, and from services work including MRO—an area not generally a natural fit for GKN. It also owns 43% of Belgian aerospace firm Sabca; the rest is owned by Dassault Aviation and other small stakeholders.

GKN hopes to see Fokker's profitability rise over the next three years, but also wants to make cost savings equivalent to 3% of sales by 2018. It does not rule out selling parts of Fokker. "We want to run Fokker the GKN way," says Stein.

The acquisition is expected to close by the end of 2015, assuming it clears competitive and regulatory hurdles both in the European Union and U.S. Trade unions are also being consulted, and the deal must clear International Traffic in Arms Regulations because of Fokker's defense work.

The purchase is not without risk, however. The Dutch company is in dispute with U.S. authorities over sanction-busting sales of aircraft parts to Iran and Sudan. GKN officials say mitigations for this case had been considered as part of their due diligence.

Fokker will retain its brand name but become a new operating unit within GKN Aerospace. Its headquarters will remain in the Netherlands. GKN also says Fokker will keep its R&D and manufacturing facilities there, and maintain its partnerships with the Dutch government and education sectors.

Lessons Learned

SpaceShipTwo accident findings to benefit safety of 'fledgling' commercial space industry

Guy Norris Orlando

The NTSB says the fatal inflight breakup of SpaceShipTwo on Oct. 31, 2014, was caused by the co-pilot's earlier-than-planned unlocking of the feathering tail mechanism, but it faults the vehicle manufacturer, Scaled Composites, for inadequate training and procedures, and it suggests a design modification could have mitigated human error.

The report, which was reviewed by the NTSB July 28, confirms the board's preliminary findings made within days of the loss of the SS2 during its fourth powered test flight. NTSB Chairman Christopher Hart also said a key contributor was Scaled's "failure to consider and protect against the possibility that a single human error could result in a catastrophic hazard to the SpaceShipTwo vehicle."

The report found that the aircrew procedures used by Scaled, which was in the final stages of flight-testing the vehicle before transferring it to Virgin Galactic, did not require a challenge/response protocol prior to unlocking the feather handle. It also determined that although the catastrophic consequences of unlocking the feather system in the transonic region were known within the program, this was not formalized in either crew training or the pilot handbook. A further contributing cause was the lack of an inhibit mechanism to automatically prevent premature movement of the feather system.

Details in the report of the final moments of the flight reveal that the feather system was unlocked as SS2 accelerated under rocket power through Mach 0.92 at 10:07:28, some 9 sec. after release from the WhiteKnightTwo (WK2) carrier aircraft and an estimated 14 sec. before the vehicle would have reached Mach 1.4, the minimum speed at which the tail was designed to be unlocked. Telemetry, in-cockpit video and audio data confirmed that co-pilot Michael Alsbury announced "unlocking" as Mach 0.92 was passed and vehicle breakup occurred within the next 4 sec. The other test pilot, Peter Siebold, director of flight operations at Scaled, was thrown clear and, though badly injured, survived a parachute landing.

It remains unknown why Alsbury unlocked the feather mechanism early, but NTSB investigator Katherine Wilson says one possibility is that he may have wanted to reduce the risk of having to abort the test. Under the conditions of the test card, the system had to be unlocked by Mach 1.8 at the latest to prevent the mission from being aborted. Scaled says Mach 1.8 was, at the time, assessed as the maximum speed an unfeathered reentry could be accomplished in the event the locks failed in the locked position. The manufacturer says the exact bounds for what speeds the feather unlock was supposed to happen were specific to each flight based on test variables, thus explaining why the unlocks occurred earlier on previous flights without incident.

The feathering device was originally conceived by Scaled Composite designer Burt Rutan as a "carefree" and stable reentry method for recovery of SpaceShipOne and is designed to be activated outside of the thicker layers of the atmosphere before the vehicle begins its descent. The system operates by rotating the vehicle's twin tail booms upward about the trailing edge of the wing by around 65 deg. Following reentry, the actuators rotate the booms down into the flush position for approach and landing.

To ensure structural integrity as SS2 passes the transonic region between Mach 0.8-1.2 (where uploads on the tail would normally overpower the feathering mechanism actuators), the system incorporates a set of lock hooks. These hooks are disengaged when the crew moves the unlock handle. In order for feathering to be commanded by pilots, a feather handle must be moved in addition to the unlock handle. Although the feathering system already had been deployed during earlier flight tests of SS2, these activations either occurred in thinner air at higher altitudes or at much slower speeds than the ill-fated Oct. 31 flight. The feathering system was first used on a powered flight during the second rocket-propelled sortie on Sept. 5, 2013, when SS2 reached Mach 1.43 and an apogee of 69,000 ft.

In its submission to the NTSB, Virgin Galactic says the second SS2, currently nearing completion at sister operation The Spaceship Co. (TSC), already has been modified with an automatic mechanical inhibit device to prevent locking or unlocking of the feather during safety-critical phases. An explicit warning about the dangers of premature unlocking has also been added to the checklist and operating handbook and a formalized crew resource management (CRM) approach, already used by Virgin for its WK2 operations, is being adopted for SS2. This will include call-

NTSB

SS2's feathering tails are extended and retracted by pulling the green actuation handles mounted above the rocket motor control switches. The metallic feather locking/unlocking handle is shown (left) in the upper, locked position and (right) in the lower, unlocked position.

outs and a challenge/response protocol. While the report cites CRM issues as a likely contributing cause, Virgin says there is no plan to modify the cockpit display system.

Responding to the NTSB hearing in a video, Virgin Galactic founder Richard Branson says the investigation will "help make the fledgling commercial space industry safer and better." He also confirmed the design and installation of the feather lock safety mechanism and added that, with the investigation complete and lessons learned from the accident, the company "can now focus fully on the future with a clean bill of health and a strengthened resolve to achieve its goals."

The carrier adds that unspecified modifications to the second SS2 are in progress to eliminate vulnerabilities to single-point human performance actions. It also adds that an external safety review team, which conducted an initial review of the SS2 vehicle as well as Virgin Galactic's and TSC's engineering flight test and operations functions, will perform further reviews before flight tests resume, and prior to the start of commercial service.

Virgin Galactic also says pilots for flight-test and service operations will be test pilot school graduates with a minimum of 1,000 hr. commanding military jet-powered aircraft and experience in multi-engine non-centerline thrust aircraft as well as multiplace crewed air- and/or spacecraft.

Important to the continuation of the SS2 program, the report also confirms that the polyamide-based hybrid rocket motor fuel being flight tested for the first time on the day of the accident was not a contributing factor. In its submission, Virgin says the rocket motor "met or exceeded expectations, running smoother and with less vibration than during any previous powered flight."

Wing Theory

Flight tests to confirm a 1930s theory on wing design lead to a Mars aircraft proposal

NASA PHOTOS

Graham Warwick Washington

A small, unmanned aircraft that would deploy from a cubesat released by a Mars lander as it enters the planet's atmosphere is being studied by NASA. The flying-wing UAV could reconnoiter for future astronaut landing sites as it descends to the Martian surface.

The Prandtl-M unmanned aircraft is a new direction for research into an old configuration at NASA Armstrong Flight Research Center. The design is named after German engineer Ludwig Prandtl, who developed many of the key theories of aerodynamics. Using subscale models, the project set out to prove Prandtl's theory that adverse yawing of an aircraft in a turn could be overcome with wingtip aerodynamics alone, without requiring vertical tails or rudders.

Funded by NASA headquarters' education budget and using summer interns, Armstrong built two 12-ft.-span, 15-lb. radio-control tailless flying wings—Prandtl-D1 and D2—to prove the theory. NASA is now preparing to fly a larger model, Prandtl-D3, with 25-ft. span and weighing 40-50 lb., says Al Bowers, Armstrong chief scientist and program manager for Prandtl-D and -M.

Earlier this year, NASA Armstrong engineer Dave Berger came up with the idea of deploying a Mars aircraft from a cubesat. "After the Curiosity rover touched down, the first thing it did was dump 27 kg [60 lb.] of tungsten on the surface. So why not carry cubesats as ballast?" Bowers asks.

The 2-ft.-span UAV would be stored rolled up inside a 12 X 4-in. cubesat that would be released from the aeroshell carrying a rover the surface of Mars. After deployment from the cubesat, the 2.6-lb. vehicle—weighing 1 lb. in Mars's gravity—would fly for about 10 min., covering 25 mi. before gliding down to land. In Mars's thin atmosphere, the UAV would fly at Mach 0.6 and "survey a fairly large area," says Bowers.

Deployed from a cubesat, the 2-ft.-span Prandtl-M would map the surface of Mars.

The project began in March, with funding from NASA's Flight Opportunities program. This year a prototype is to be dropped from a balloon at 85,000 ft., simulating Mars's atmosphere, to test the autopilot and a small science payload—either a mapping camera or high-altitude radiometer. "Next year we will package the aircraft into a cubesat container and take it up on a balloon," says Bowers. The container will be dropped and Prandtl-M will deploy from the cubesat, unfold, and fly for up to 5 hr. as it glides back to a landing at the launch site.

A third mission is being discussed for 2017. The cubesat would be launched on a sounding rocket to 450,000 ft. and released to fall back into the atmosphere. At 110,000-115,000 ft. the aircraft would deploy from the cubesat as if it were over the surface of Mars. "If Prandtl-M completes a 450,000-ft. drop, then I think the project stands a very good chance of being able to go to NASA headquarters [to seek] permission to ride to Mars with one of the rovers," says Bowers. The next opportunity in is 2022-24.

Prandtl-D models have provided data on pressures and loads on the flying wing.

Safety Scrutiny

Oversight deficiencies cause more headaches for Thailand's airlines

Thai Airways is one of the carriers affected by international restrictions.

JOEPRIESAVIATION.NET

Adrian Schofield

As the FAA considers whether to take action over air safety concerns in Thailand, airlines there are facing a mounting list of restrictions that could severely dent international growth plans.

The U.S. appears likely to follow aviation authorities from other countries by blocking new service from Thai carriers. While existing flights to these nations can continue, the disruption to expansion plans and reputational damage will be a blow to an airline sector still recovering from a demand slump caused by Thailand's political upheaval.

The irony is that while the country's airlines face the consequences, the problems lie with the national regulator that is supposed to oversee their safety compliance.

Safety issues were first identified by the International Civil Aviation Organization (ICAO) during an audit of Thailand's Department of Civil Aviation (DCA). ICAO found what it classed as significant safety concerns (SSC), mainly relating to how the state certifies its airlines. The issues range from staffing levels to manuals and procedures.

After the DCA was informed, the agency was given 90 days to resolve the concerns. Although some measures were initiated to allow it to start recertifying all of the airlines, it did not meet the deadline. So Thailand became the 13th nation to be "red-flagged" on ICAO's aviation safety list.

ICAO says it is working with Thai authorities to help them clear up the SSCs. Thailand's deputy transport minister led a delegation to ICAO recently and "stressed his country's commitment, at the highest level, to continue to address and resolve any deficiencies we identified," ICAO says. This could be a lengthy process, however, as there have been delays in beginning the major task of airline recertification.

The red flag status does not in itself impose any restrictions, but it serves as a guide to national aviation authorities. The ICAO warning has prompted various actions from different countries.

Japan was among the first to respond, blocking most charter flights and preventing Thai carriers from starting new services. Others, including South Korea and Indonesia, have taken similar steps.

The reactions of the FAA and the European Aviation Safety Agency (EASA) are regarded as particularly significant, as these are the most influential aviation regulators. EASA has yet to impose any restrictions, and Thai carriers were not included in the latest update of the European Union's list of banned or restricted airlines.

All eyes are now on the FAA, which sent a team to Thailand to conduct its own audit during the week of July 13. Thai officials were notified that oversight deficiencies were found, and were given 65 days to address them.

The FAA audit is based not on the U.S. agency's own regulations, but on ICAO safety standards. Given the magnitude of the problems already identified by ICAO, it appears likely that they will not be fixed to the FAA's satisfaction within the 65 days.

At that point, the FAA will hold discussions with Thai authorities and decide whether to downgrade the nation's safety status from Category 1 to Category 2. According to the FAA, a Category 2 rating means a country either lacks laws or regulations necessary to oversee air carriers in accordance with minimum international standards, or that its civil aviation authority is deficient in one or more areas, such as technical expertise, trained personnel, record-keeping or inspection procedures.

Airlines from Category 2 countries cannot begin new service to the U.S. Existing flights can continue but cannot be expanded, and the same applies to code-share arrangements. Thai Airways operates a Los Angeles route, although it is suspending it as of Oct. 25 as part of network cuts.

So far, the carrier most affected by overseas restrictions is Thai AirAsia X, a long-haul low-cost carrier affiliated with the AirAsia group. The airline was granted short-term exemptions by Japanese regulators to begin a Bangkok-Sapporo flight in May. However, it had to use aircraft registered to its Malaysia-based parent and had to reapply for permission to operate the flight.

These requirements became too onerous for Thai AirAsia X, and it has decided to suspend the route as of Aug. 1 until the Japanese restrictions are removed. Existing flights to Tokyo and Osaka are allowed to continue, but the inability to expand in Japan is a major blow to the carrier's growth plans.

NokScoot, a Thai long-haul low-cost carrier that launched this year, was also targeting Japanese and South Korean flights. It now has to focus on different markets.

In the long-term, however, actions by foreign governments are a greater potential threat to Thai Airways. With a broader long-haul network, it is more exposed to restrictions on international service. Customer perception—whether warranted or not—could cause passengers to book on competing airlines instead.

Thailand is not the only Southeast Asian country to have its safety oversight faulted by overseas authorities. Indonesia has been downgraded to Category 2 by the FAA since 2007, and all but four of its carriers are prohibited from flying to the EU. The Philippines was also downgraded in 2008 following an unfavorable ICAO audit; restrictions were not removed until last year.

Philippine Airlines was forced to continue using Boeing 747-400s on its U.S. routes, because the FAA downgrade meant it was not allowed to even change the aircraft type. Soon after the restrictions were lifted, it switched to using more efficient Boeing 777-300ERs and retired the 747s.

Japan also blocked capacity additions by Philippine operators, preventing low-cost carriers in particular from entering the market. This kept supply artificially low, and when the restrictions were removed airlines ramped up flights.

Safe Pilots

Germanwings disaster leads to backing for stronger pilot screening

Sean Broderick Washington and Cathy Buyck Brussels

PAUL BANNWARTH/AIRLINERSGALLERY.COM

That pilots can be a threat to air safety has been a key and painful lesson from the crash of Germanwings Flight 9525 in the French Alps. Now a European Commission-initiated task force has presented its views on the implications of the disaster, along with some far-reaching recommendations.

The task force is calling for more robust pilot screening and for airline drug and alcohol programs with random testing. The Commission says it will consider these and four other suggestions "before deciding on future steps."

The report was delivered to the EC in mid-July and released July 17. The task force, called for by the EC after the French Civil Aviation Safety Investigation Authority (BEA) released its preliminary report on Flight 9525 in early May, was set up "to assess the adequacy of European air safety and security rules," the EC says.

The 14-member task force, led by the European Aviation Safety Agency (EASA), embraced several common themes that emerged early in the probe. Chief among them is support for a policy of requiring at least two people on the flight deck at all times, a procedure many carriers in Europe and elsewhere put in place after the Germanwings disaster.

The task force also suggested a "robust" oversight program for aeromedical examiners and called for creation of a European aeromedical data repository. It also backs both a psychological evaluation for pilots as part of the screening process and "pilot support systems" within airlines.

The report calls for random drug and alcohol testing "at least . . . in conjunction with the initial Class 1 medical assessment or when employed by an airline, postincident, postaccident, with due cause, as part of follow-up and after a positive test result." That proposal had also been made by Lufthansa CEO Carsten Spohr. He argued testing for drugs in particular might turn up cases of pilots in psychological distress by finding traces of antidepressants. But the idea brought up concerns over privacy rights.

Past efforts to put Pan-European aviation-worker testing programs in place ran into challenges because of the myriad national laws that come into play.

During the FAA's latest effort to expand its programs to approved maintenance facilities outside the U.S., the International Air Transport Association (IATA) was among those that pointed to the challenges, especially in Europe, where EASA oversees 32 member states.

"Drug and alcohol testing regulations vary across the [European Union], with some countries banning pre-employment testing . . . and many countries requiring the test results [be] conveyed to the employer in a limited 'fit or not fit for duty' declaration," IATA told the FAA in comments filed in 2014. "Labor protections are significant in the EU and serve principally to protect employees' privacy and livelihood. In some cases, where testing is generally banned as an invasion of privacy, exemptions are made for 'safety-sensitive' workers, who may be tested in limited circumstances. However, the conditions under which and the procedures through which testing is permitted vary extensively, and testing is still banned in certain states even when suspicion is present."

This Germanwings aircraft was intentionally flown into a mountain by its first officer, killing all 150 people onboard.

The report says it "may be appropriate to obtain a complete EU-wide picture of national drugs and alcohol legislation that affects pilots by surveying the competent authorities," and "extend[ing] the target group for the random testing program to other safety-critical professionals . . . might be considered."

The EC says the report "strives to reach a balance between medical secrecy and safety, and not to create additional red tape for airlines."

The group looked at several issues it ultimately left out of the recommendations. Among them was the manual cockpit door locking systems mandated after the 9/11 attacks. "The task force has not identified presently suitable alternatives to the manual lock to guarantee security in case of the failure of the automatic system," the report says. "It is also noted that there are specific cases where the manual lock has proven useful."

The next steps are a review of the recommendations and related input from safety experts, including accident investigation agencies.

"Where legislative action is to be taken, EASA will be requested to develop concrete proposals, which will then be included in EU aviation safety regulations," the EC said.

"Key players in aviation and medical science worked closely together within the task force," says Patrick Ky, EASA executive director and task force chairman. "This report is the result of a thorough analysis with practical recommendations, so that such a tragic event does not happen again. EASA is ready to take the next necessary steps, applying the lessons learned."

The European actions are part of a broader effort triggered by the Germanwings disaster, in which the flight's first officer apparently locked the captain out of the cockpit and intentionally flew the Airbus A320 into the ground during a flight from Barcelona, Spain, to Dusseldorf, Germany. Germany's air navigation service provider has called for studying systems that would allow aircraft to be remotely controlled from the ground during emergencies. The FAA has set up a task force to study pilot mental fitness with a goal of providing recommendations by year-end. A separate task force led by the German transport ministry reached similar conclusions to the EU-wide initiatives.

Small Launch, Big Hopes

USAF's rail-launched rocket designed for transfer to industry to stimulate commercial market

Amy Butler Washington

The U.S. Air Force is preparing for the inaugural launch of a small rocket system designed not for its high technology but for simplicity, low cost and to stimulate the commercial market.

The so-called Super Strypi rocket is set to launch 13 payloads Oct. 29 from the Pacific Missile Range Facility in Hawaii. Developed by the Air Force—under the Operationally Responsive Space (ORS) office and with help from Sandia National Laboratories—the goal is to ultimately transition the design to industry for production.

"We are trying to turn this into a commercial system at a price point where commercial [companies] could launch it. If you look at where the major constellations are, they want to launch a lot of satellites on a couple of big rockets and get their big constellations fielded," says Col. John Anttonen, who oversees the Air Force's ORS office. He is referring to mushrooming interest from telecommunications and imaging companies intent on fielding flocks of small satellites into low Earth orbit for commercial interests. "ORS-4 [the Super Strypi mission] is laying a foundation for future ORS office small, responsive launches while resetting the bar for small launch costs." The production price is $15 million; Anttonen hopes to reduce that to $12 million per launch.

These commercial companies plan to launch dozens of satellites at a time. Super Strypi could be employed as a primary launcher but is more likely to be useful as a replenishment vehicle option for constellation owners who experience small satellites failures in orbit. While such companies are interested, Anttonen says a successful Super Strypi program could also benefit ORS, with its plans to field a greater number of small satellites. He hopes to help rocket companies interested in building the system make a business case, and says the market indicates it could support 10 launches per year.

This focus on low cost directed designers' attention to an old system, not new technology. Super Strypi draws on 1960s technology. It will be rail-launched, spin-stabilized and will use simplified avionics and fins for guidance. What is new, however, is its three-stage motor stack, designed by Aerojet Rocketdyne. That is also the highest risk portion of the platform.

The first launch has been delayed about two years to allow time to explore a problem found in the first stage. After a test burn, forensics showed the solid propellant had burned through insulation lining the case. It had not compromised the case itself, Anttonen says. After conducting a risk assessment for the launch, Lt. Gen. Samuel Greaves, Space and Missile Systems Center commander, and each customer agreed to allow the launch to go forward without a fix and accept the possibility of a malfunction. "It is a relatively easy thing to fix [in production,] but retrofitting it after you have done it is difficult," Anttonen says. The additional risk does not move the launch beyond the existing medium/high category it was already occupying because it is a new system, he said. The final seconds of first-stage flight are when there is the most risk.

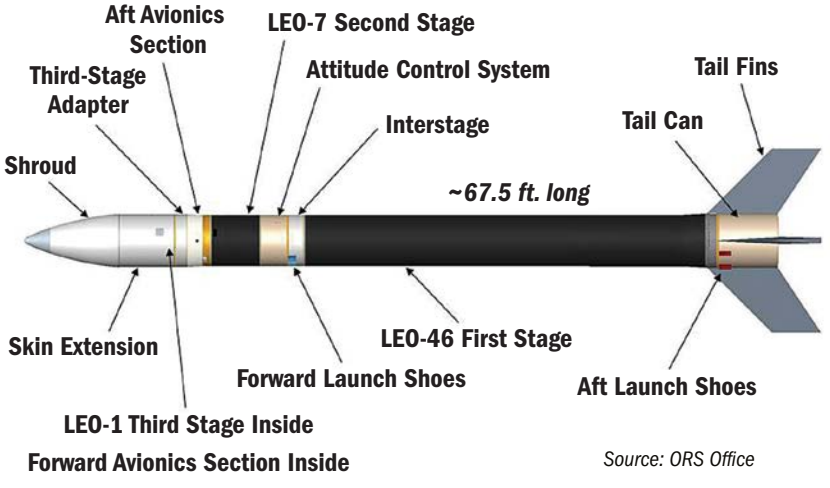
The University of Hawaii-Hawaii Space Flight Laboratory's HiakaSat thermal hyperspectral imager is the primary payload; 12 other cubesats are also being launched.

Super Strypi is designed to deliver 300 kg (661 lb.), 475 km (295 mi.) into low Earth orbit.

The rail-launch design simplifies flight termination system (FTS) requirements, reducing cost. While the first flight will use a more standard FTS, the goal is to introduce an autonomous one, which has already operated in "shadow" mode on two missions. It will fly on Super Strypi, again in shadow mode, to complete a validation requirement for future use. The system is designed to require an "active" command to proceed to the next stage. Without that command, the rocket will take a ballistic trajectory and splash down. For the inaugural flight, a mission flight control officer will perform this function, but ultimately the automated system will be used.

Use of that system is expected to reduce range cost to $3 million per launch from $5 million.

Anttonen says the Air Force intends to make the Super Strypi data package available to companies interested in building it, and industry could produce the design within about two years.



Source: ORS Office

The USAF Super Strypi pulls from sounding rocket technologies in an attempt to form a low-cost, small launch option for industry.

Hard Lesson

Steel strut is likely cause of Falcon 9 launch failure

Frank Morring, Jr. Washington

SpaceX plans to strengthen its preflight test process to prevent a recurrence of the June 28 failure that claimed a load of food, clothing and hardware bound for the International Space Station (ISS), and modify software so its Dragon capsule can try to "save itself" in a future mishap.

Elon Musk, the company's founder, CEO and "chief designer," says an out-of-spec upper-stage strut is the prime suspect in the mishap. He told reporters July 20 the upper stage exploded while the first stage was still firing after a high-pressure helium bottle broke loose in the upper stage's liquid oxygen tank and overpressurized the structure.

Accelerometer data allowed failure-review engineers to pinpoint the location of the anomaly at the bolt head on the single steel strut holding the helium bottle in position. Musk says other telemetry suggested the tank rose toward the top of the LOX tank, releasing helium pressurized at 5,500 psi before it resealed itself when the line linking the tank to the stage's Merlin engine kinked and closed "like a twisty tie."

"We've flown several hundred such struts on every Falcon 9 vehicle, meaning there is a cumulative flight history of several thousand of these struts," says Musk. "Moreover, the strut that we believe failed was designed and material-certified to handle 10,000 lb. of force, but actually failed at 2,000 lb. of force, which is a five-fold difference. Examining detailed close-out photos of stage construction, we don't see any visible flaws or damage of any kind."

SpaceX has briefed NASA, the U.S. Air Force and other customers on future Falcon 9 launches, as well as the FAA, which licensed the commercial launch mission, Musk says. He emphasizes that the findings are preliminary and may be updated as more data come in. This could include the recovery of vehicle debris from the ocean floor downrange from its Cape Canaveral launch pad using a submersible vehicle to search the dark depths.

The SpaceX founder says until the June mishap his company had not experienced a failure since Aug. 3, 2008, when a Falcon 1 failed to reach orbit after launch from Kwajalein Atoll in the Marshall Islands. At the time, he says, there were only about 500 SpaceX employees. In the interim, 3,500 have been hired who have never experienced a setback. The CEO says he emails all employees prior to every launch urging them to warn of potential risks "whether managers agree with it or not," but notes that this missive didn't generate the required level of "paranoia."

"The 20th time I send that email, it just seems like, you know, 'there's Elon being paranoid again,'" he says. "So maybe it doesn't resonate with the same force. But I think now everyone at the company appreciates the type of difficulties to get rockets to orbit successfully, and we'll be the stronger for it."

Identical struts are used to hold down helium bottles in the Falcon 9 main stage as well. In the future, Musk says, the company will conduct a "pull test" on every strut flown to ensure it meets specifications, a process the company performed on identical struts on the ground to begin validating its theory about the root cause of the failure.

Although SpaceX is known for building Falcon hardware in-house, Musk says the company still buys "hundreds" of flight components, including the strut that failed, from outside vendors. He declined to identify the manufacturer, saying the disclosure "just results in recriminations." But the part will be redesigned, and may be procured from a different vendor, he says.

"We were relying on material certification from the supplier," he says. "In the future we will be individually testing each strut."

Even though telemetry showed a drop in helium-system pressure, followed by a return to normal—a condition Musk termed "quite confusing"—enough helium was released into the full LOX tank to blow out its lightweight

SPACEX

structure. Video of the event shows the nine-engine main stage still firing after the upper stage exploded, and appears to show the Dragon capsule loaded with more than 5,500 lb. of space station cargo dropping intact toward the Atlantic Ocean. Musk says the Dragon continued to send telemetry until it fell out of range below the horizon.

"If the software had initiated the parachute deployment, then the Dragon spacecraft, we believe, would have survived," he says. He notes that for future missions—even for the cargo version of Dragon—contingency software will be installed allowing the vehicle to attempt to save itself.

The mishap will probably push the next Falcon 9 launch back to September at the earliest, and the first flight of the Falcon 9 Heavy originally planned this year will be pushed back until April 2016 or later. Musk says it remains un-

Overpressurization in the Falcon 9 upper stage, caused when a helium pressure bottle broke free, is the likely cause of the June 28 failure on a flight to the space station.

clear who the customer will be on the return to flight.

The mishap—and earlier failures of cargo missions on an Orbital ATK Cygnus vehicle and a Russian Progress freighter—should not affect the company's plans to finish developing a cargo version of the Dragon to deliver crews to the ISS, Musk says. And NASA's top space station manager says it will not seriously hinder research on the station. Three more crewmembers are scheduled for launch to the station on July 23, which will bring the orbiting outpost back to its normal complement of six so research can continue at as fast a pace as possible given the loss of supplies and science hardware.

"The industry, the program, is very resilient to this sort of anomaly, and I think you can see it in the fact that we're standing here today, we're still talking about research," says Mike Suffredini, NASA's ISS program manager, speaking at a station-utilization conference in Boston July 7. "We're not talking about modifying what we're doing on orbit."

Japan is scheduled to launch a big H-II Transfer Vehicle (HTV) to the ISS on Aug. 16, and Suffredini says that most of the research equipment set for that mission will fly as planned. The only exception will be some gear that was to be pre-positioned for experiments due to arrive on a future SpaceX flight, but will be delayed to make room for food and other crew needs.

"That's the only change we made, so all the research on the HTV remained," he said. "We did have to modify some of the other supplies to make sure we had everything we needed."

SpaceX is also in competition for national-security launch business after a bruising battle for certification to compete that ended before the June 28 mishap. USAF Secretary Deborah James says the mission failure should not hurt the company's chances of winning such work, even though it happened just as the company was preparing its reply to the first Air Force solicitation for competitive launches in the Evolved Expendable Rocket Vehicle family since 2006, when the United Launch Alliance (ULA) monopoly was formed by amalgamating Boeing and Lockheed Martin's then-struggling rocket businesses.

"The fact that this accident occurred certainly will not affect SpaceX's certification," says James. "It will not affect an upcoming competition where I expect SpaceX to compete. Remember, between a competition and an actual launch of a system, it is usually a couple of years. So in order to recover from that, there would be a couple of years in there to be able to demonstrate there was a root cause and a corrective action."

The upcoming competition to launch GPS III spacecraft will include a series of pass/fail technical requirements. If both providers pass on each, as expected, the competition will come down to a price shootout where SpaceX's low pricing puts the company in a good position.

The mishap does, however, potentially benefit ULA. The Air Force is requesting authority to use more Russian-built RD-180s for military missions. For that to happen, Congress must rescind limits on the use of these engines for military missions put in place after Moscow annexed Crimea last year. ULA is hoping to get the relief, as it would keep its Atlas V—its least expensive launcher—in the military business longer.

"As much as we dislike [Russian President Vladimir] Putin . . . in retrospect—10 or 12 years ago—we should never have fallen in love with this Russian engine, [but] we are where we are," James says. "The most important thing to me is assured access to space . . . two providers to get us to space. This terrible mishap has reminded us that space is a very complicated, dangerous domain, and it really is hard science. Things could go wrong. Things could go wrong for any of the companies. . . . What we are trying to say to the Congress is 'allow us a little bit more flexibility and give us a few more of these Russian engines so we can assure assured access to space.'"

DEFENSE

High-Speed Helos

With merger, Sikorsky and Lockheed Martin rotorcraft portfolios could overlap

Graham Warwick Washington

It is back to the future for Lockheed Martin with its planned $9 billion purchase of helicopter-maker Sikorsky.

In the 1960s, Lockheed had a rotorcraft business and its focus was on developing a high-speed helicopter—a key technology that will come with the Sikorsky acquisition.

Sikorsky also is working in two key areas—platform autonomy and intelligence—that could add to Lockheed Martin's technology portfolio, but also could overlap, forcing internal decisions on which of the competing approaches to pursue.

The helicopter manufacturer's technology work is centered on Sikorsky Innovations, an advanced research and rapid prototyping organization established in 2010 and inspired in part by Lockheed's Skunk Works. Innovations grew out of Sikorsky's X2 Technology Demonstrator project, a $50 million, company-funded effort to fly an experimental high-speed helicopter.

Where Lockheed's past high-speed helicopter was the 212-kt., rigid-rotor AH-56 Cheyenne, developed for the U.S. Army but canceled in 1972, Sikorsky's was the XH-59A Advancing Blade Concept. This coaxial-rotor, twin-turbojet rotorcraft reached 263 kt. in the mid-1970s, but was abandoned until Sikorsky in 2006 brought new technologies to the concept to create the X2.

The rigid coaxial-rotor, pusher-propeller X2 reached 250 kt. in level flight in September 2010. In October of that year Sikorsky launched an industry-funded, $200 million program to build two prototypes of the S-97 Raider high-speed light tactical helicopter. Its target was the U.S. Army's Armed Aerial Scout (AAS) requirement. But by the time the first Raider flew in May, AAS was on the shelf, a victim of budget cuts.

Sikorsky continues to promote the Raider to the Army as an armed scout, but in the absence of a requirement the high-speed helicopters will provide risk reduction for the Sikorsky/Boeing SB-1 Defiant Joint Multi Role (JMR) technology demonstrator. A larger instantiation of the X2 configuration, the SB-1 is scheduled to fly in 2017. JMR is a precursor to the Army's planned Future Vertical Lift (FVL) Medium program to replace first the Sikorsky UH-60 Black Hawk, and later the Boeing AH-64 Apache.

Lockheed Martin has not been idle since the Cheyenne was canceled, but its role within the helicopter industry

is now as a system integrator and mission-system supplier. In addition to being prime contractor on the U.S. Navy's Sikorsky MH-60R/S Seahawk, Lockheed was on the EADS (now Airbus) team offering the AAS-72X for AAS, and is teamed with Bell Helicopter on the competing V-280 Valor tiltrotor for the JMR technology demonstration.

Building on their Seahawk association, Sikorsky selected Lockheed as mission-system integrator for both the Navy VH-92A presidential helicopter and Air Force HH-60W Combat Rescue Helicopter programs—a consolation for Lockheed after its AgustaWestland AW101-based VH-71A Kestrel presidential helicopter program was canceled in 2013 because of cost overruns.

Lockheed's role as mission-system developer on Bell's JMR/FLV team does not conflict directly with owning Sikorsky, as Boeing has the avionics lead on the Defiant system, but internal firewalls will be required. Neither team has yet made final decisions on the FLV mission system, definition of

Rotating Businesses

Lockheed's purchase of Sikorsky and IT divestitures spins it closer to Washington

Michael Bruno Washington

Lockheed Martin's planned acquisition of Sikorsky Aircraft from United Technologies Corp. ultimately could be more defining for Lockheed, the Pentagon's leading prime contractor, than for helicopter manufacturer Sikorsky or even the rotorcraft market.

The July 20 announcement that Lockheed will buy Sikorsky means the latter essentially enjoys a soft landing from what was an uncertain and—for the U.S. Defense Department—potentially fraught outcome as either a stand-alone business or even as part of a European-based contractor (*AW&ST* June 22-July 5, p. 38).

Indeed, the Sikorsky name, its manufacturing, and its major research-and-development efforts are expected to largely continue, according to Lockheed officials. Rep. Rosa DeLauro (D-Conn.), a vocal Sikorsky advocate in Congress, says she was told existing collective bargaining agreements between Stratford, Connecticut-based Sikorsky and its unions will remain intact.

Yet for Bethesda, Maryland-based Lockheed, Sikorsky represents an all-in approach to being a U.S. contractor, even as other companies look to diversify revenue generation and cut lower-margin government work—starting with UTC's decision to sell Sikorsky, its least-profitable business segment.

SIKORSKY/BOEING CONCEPT

Sikorsky is teamed with Boeing on the SB-1 Defiant JMR demonstrator (pictured). Lockheed Martin is on the competing Bell V-280 Valor team.

which is deliberately lagging the platform by several years to allow technology to evolve. But longer term, Lockheed may face a choice on where to invest its R&D resources—platform or mission system.

And, as was the case when the Cheyenne was canceled to be replaced by the more conventional, 158-kt. Apache, none of the companies involved in FVL know whether the Army will hold to its desire for higher-speed—and likely higher-cost—rotorcraft to replace its UH-60 and AH-64 fleets. So the alliances struck for JMR may have to be revisited later this decade.

Lockheed's Skunk Works, meanwhile, is a member of the Sikorsky team working on the Darpa VTOL X-Plane program to demonstrate a vertical-takeoff-and-landing aircraft that can hover as efficiently as a helicopter but reach a speed of 300-400 kt. Sikorsky's design is the tailsitting Unmanned Rotor Blown Wing concept. Aurora Flight Sciences, Boeing and Karem Aircraft also are working on designs. Subscale prototypes are now in flight test.

Of Sikorsky Innovations' other technology pillars, the autonomy thrust brings it closest to competitive conflict with Lockheed. Using an autonomy system flying in an S-76 testbed under Sikorsky's internally funded Matrix Technologies program, the company is modifying an ex-Army UH-60A into an optionally piloted vehicle. Sikorsky's aim is to demonstrate to the Army that autonomous Black Hawks can carry cargo at a cost per mile that competes with truck convoys.

This is the mission Lockheed and Kaman have been pursuing with the unmanned K-Max external-lift helicopter. The K-Max proved its capability on U.S. Marine Corps resupply missions in Afghanistan, but an Army analysis for Congress in 2014 concluded it would be more expensive to acquire and operate new K-Maxes than use Black Hawks for the cargo mission—a conclusion Lockheed has disputed.

Independently, the companies are working on collaboration between unmanned helicopters and ground vehicles. Under an Army contract, Lockheed in 2014 demonstrated the K-Max could lift the company's Squad Mission Support System unmanned ground vehicle (UGV) into a simulated contaminated area to conduct an autonomous reconnaissance mission. Sikorsky is working with the Army to demonstrate a similar capability this year using an unmanned UH-60MU to carry a Carnegie Mellon University UGV.

Sikorsky's investment in the Matrix program and its S-76 autonomy testbed has won the company a contract for Darpa's Alias program to develop a robotic co-pilot that can be installed in the cockpit of existing aircraft to reduce crewing requirements, then removed and moved between aircraft types as required. Lockheed also received a contract, as did Aurora.

An unstated goal of Sikorsky's technology research was to unseat Lockheed as system integrator on future rotorcraft programs. This includes the Navy's next shipboard helicopter, dubbed MH-X and likely to be a marinized version of the Army's FLV Medium utility replacement for the UH-60. Sikorsky's acquisition will render that goal moot, but raises competitive concerns unless another equally capable rotorcraft system integrator steps forward.

Even allowing for overlap, Sikorsky's work on certifiable autonomy and more affordable fly-by-wire can only strengthen Lockheed's position as a mission-system integrator, not only for rotorcraft but also unmanned aircraft and future transports. And lessons learned by Lockheed on the F-35 Joint Strike Fighter could complement Sikorsky's work to increase the self-monitoring and automation of platforms and introduce advanced manufacturing to reduce production costs in preparation for FVL.

Moreover, besides acquiring another prime federal platform and systems integrator like itself, Lockheed also plans to divest almost as much in noncore federal information technology (IT) business that it spent the past few years building in an effort to diversify.

Lockheed says it is conducting a strategic review of alternatives for its government IT and technical services businesses, primarily in the Information Systems & Global Solutions (IS&GS) segment, as well as a portion of the Missiles and Fire Control unit. The combined programs earn an estimated $6 billion in annual sales and count more than 17,000 employees, but will be spun off, sold, or both. The divested work will not include intelligence and cybersecurity, but could include units such as the former Systems Made Simple, a health IT solutions provider to the U.S. government that Lockheed agreed to buy last October.

Instead, Sikorsky will help Lockheed dive deeper into the $30 billion military and commercial helo market with a recognized brand, doing the kind of work Lockheed knows best, and for the largest single customer in the world, the Pentagon. "Sikorsky is a natural fit for Lockheed Martin," Lockheed Chairman, CEO and President Marillyn Hewson told Wall Street analysts and reporters. "We are purchasing an active participant in one of the largest areas of Defense Department expenditures at an attractive price."

"This is what we do, this is our core knitting," agreed CFO Bruce Tanner. "This is a long-term business. We're not buying this business for the next three years. We're buying for the next three decades."

According to executives and prepared statements, Lockheed and UTC have agreed to a $9 billion price tag for Sikorsky, about 13 times Lockheed's expected pretax earnings this year (10.3 times after tax). But they will pay only $7.1 billion after receiving a $1.9 billion tax benefit, since it is structured as an asset purchase for tax purposes under Internal Revenue Code Section 338(h)(10).

The deal is expected to close by the first quarter of 2016, although Lockheed hopes to complete it the last quarter of

this year. For UTC, the $9 billion will come in cash and may allow for other acquisitions, which its relatively new leadership has identified as a priority. Many financial analysts had expected UTC to spin off Sikorsky due to the fact that a sale entails a tax hit so the company may see only $6-7 billion in the end. Still, even that amount was persuasive enough. "The company's desire to generate working capital was a factor behind the deal," Jefferies analyst Howard Rubel says.

Lockheed plans to use $1 billion in cash on hand but will also issue $8 billion in new debt to fund the pact. Debt

Lockheed Martin Strategic Review of IT & Services

Current Structure	Potential Future State			
	Strategic Review	Retain		
Information Systems & Global Solutions		Mission Systems & Training	Missiles & Fire Control	Space
Air Traffic Management	Yes			
Technical Services	Yes			
Government/Enterprise IT	Yes			
Commercial Cyber	Yes			
Government Healthcare IT	Yes			
Mission IT & Services		✔		
Energy Solutions			✔	
Space/Space Services				✔
Missiles & Fire Control				
Technical Services	Yes			

Source: Lockheed Martin

funding, with interest rates and borrowing costs at historic nadirs, has become a popular tool for mergers and acquisitions (M&A) this year. Hewson says Lockheed is buying Sikorsky at an opportunistic time—besides the lower borrowing costs, the valuation is lower. This is in part because Sikorsky's financials have dipped due to less revenue from commercial oil and gas customers reeling from that market's drop. Still, Lockheed's reputation in financial circles could take a near-term hit.

"Although the transaction may effectively prove to be cash flow neutral, with Sikorsky's anticipated modest cash flow contribution offsetting the expected incremental interest burden on the near-fully debt-financed and full-priced acquisition, Sikorsky's current and expected development programs and related requisite investments add material risk to the company's pro forma forward cash flows," says Russell Solomon, Moody's Investors Service senior vice president.

What is more, Lockheed does not expect Sikorsky to be accretive, or profitable, to its bottom line until 2017, with proceeds from the acquisition eventually reaching at least $150 million per year. Tanner says Lockheed looks to "rapidly" integrate Sikorsky, and $80-100 million in 2016 cost savings will be found in streamlining supply chains, along with cutting some workforce and facilities. But most of the purchased company will remain, and Lockheed plans to align it under its Mission Systems and Training business segment. "More of it stays with us longer term," he says.

According to David Wireman of aerospace and defense consulting company AlixPartners, it would be a "big lost opportunity" for Lockheed to leave Sikorsky as a stand-alone, unintegrated entity. He also sees takeout opportunities in "cost-to-serve" at Sikorsky, which historically has been a challenging customer for some suppliers. Wireman does not expect much work to be relocated, other than a consolidation of program management activities to Owego, New York.

But Lockheed's divestitures were what caught many observers off guard. "Perhaps the most surprising is the move to sell or spin a large chunk of Lockheed's services portfolio, effectively calling time on IS&GS," say RBC Capital Markets analysts. "Understandably, Lockheed does not want to be the consolidator of the services sector—preferring to stick with higher-margin equipment areas like Sikorsky."

Asked why the strategy change after the buildup of recent years, Hewson and Tanner say the landscape changed, in both the number of competitors and in the willingness of the government to treat such work as a commodity that can be shopped around frequently, including to new providers. Lockheed believes the IT businesses will remain premiere providers in federal IT, but it takes moving them out of "the business structure in Lockheed Martin" for them to survive and grow.

As for the government's view of the deal, Hewson says

Lost amid news of the Sikorsky acquisition, Lockheed Martin also plans to divest nearly as much IT business.

she talked with Pentagon officials and they promised her a thorough review for industrial consolidation concerns, as might be expected. Nonetheless, Wall Street expects it will be allowed.

"We expect a close review by the Defense Department given that combining Lockheed and Sikorsky increases vertical integration in the industry," say Cowen and Co. analysts. "This may not be a showstopper given that: 1) UTC also has potential to be a systems supplier to Sikorsky on the upcoming potential Blackhawk helicopter engine competition, and 2) a Sikorsky purchase by Textron, its alternate suitor, would have combined two of the three major U.S. military helicopter builders."

Major Aerospace and Defense Deals Since 2011

Target	Buyer	Close Date	Enterprise Value (U.S. $ billion)
Goodrich	United Technologies Corp.	July 2012	$18.3
Sikorsky	Lockheed Martin	Pending	9
Alliant Techsystems' A&D Groups	Orbital Sciences Corp.*	Feb. 2015	5
Exelis	Harris Corp.	May 2015	4.75
Avio S.p.A. Aviation Business	General Electric	Aug. 2013	4.3
Titanium Metals Corp.	Precision Castparts	Dec. 2012	3
Firth Rixson	Alcoa	July 2015	2.85
StandardAero	Veritas Capital	July 2015	2.1**
RTI International Metals	Aloca	July 2015	1.5
Aeroflex	Cobham	Sept. 2014	1.46
Arinc	Rockwell Collins	Dec. 2013	1.4
TASC	Engility	Feb. 2015	1.3

** Orbital/ATK transaction was tax-free, stock-for-stock merger **estimate* *Source: Houlihan Lokey*

For the rest of the industry, Lockheed's purchase of Sikorsky may not matter much, according to Byron Callan of Capital Alpha Partners. "It's not clear to us that this is a game changer for the defense sector, at least to the extent that other contractors need to snap up helicopter operations of Textron or Finmeccanica. Boeing certainly has the resources to keep its helicopter programs in good shape, and the same could be said of Airbus," he says.

In the end, it may matter only to Lockheed, Sikorsky and the record keepers. "A Lockheed Martin buy of Sikorsky is not likely to trigger strategic countermoves by other contractors, though it should firmly establish 2015 as a record year for defense M&A, since 2000."

Better Late . . .

Automatic takeoff and landing eyed for Reaper in fiscal 2017

Amy Butler Washington

Pressed with ongoing training and retention problems with its unmanned aerial vehicle (UAV) pilots, the U.S. Air Force has finally opted to allow for the use of an Automatic Takeoff and Landing System (ATLS) for its General Atomics MQ-9 Reaper aircraft.

This new program is one of a handful of measures to help relieve the service's overstressed UAV pilot career field. Air Force Secretary Deborah James announced the initiative as part of a push to lighten the load for Reaper pilots. USAF calls UAVs remotely piloted aircraft (RPA) to emphasize that while they provide long loiter time, they require hefty pilot numbers to support operations. Since a public chiding by former Defense Secretary Robert Gates that the service was dragging its feet in intelligence support—including delivering UAVs—for the war in Iraq, the Air Force has been in a perpetual tail chase to field the aircraft, along with enough pilots and maintainers to support them.

This spring, the Pentagon lowered by five an earlier requirement that the service field 65 combat air patrols' worth of UAVs. But the pressure is still on.

USAF has requested $37 million in the Pentagon's omnibus reprogramming for fiscal 2015 to develop an ATLS for Reaper UAVs, among other initiatives to relieve the force, James said during a July speech hosted by the National Aeronautic Association outside Washington.

Follow-up questions to the announcement were referred to the Air Force press office, which declined to provide the estimated cost for such a system, its fielding date or information on the maturity of the concept. The office said it was too early to answer these questions because the effort is still in the planning phase.

However, the fiscal 2015 omnibus funding request document obtained by Aviation Week shows planning is hardly nascent. The program will cost $56.5 million through fiscal 2020, service officials estimate in the document. Initial fielding is slated for the second quarter of fiscal 2017. The request cites three "capability gaps" ATLS addresses. First, the upgrade will comply with National Security Agency encryption demands for the command and control link. It also provides a "common data link that meets [Pentagon] standards" and will move MQ-9 command and control out of the C-band wavelength to assure operations stateside. The omnibus request was sent to Congress June 30 by Pentagon Comptroller Michael McCord.

Air Force press officers declined to comment on how implementation of the system will reduce stress on the overtaxed Reaper pilot corps or how many pilot hours will be saved. A service source, however, says pilot training can be quicker with less need to focus on these skills. What is unclear is whether the Air Force will cease training pilots to perform these operations, have a few trained pilots for them or retain a certain amount of takeoff and landing skills in the force.

The service source says the ATLS technology will be implemented in a demonstration first, to allow operators to develop procedures associated with operating it.

ATLS systems are hardly new. Foreign services use them. The U.S. Army employs one with its General Atomics Gray Eagle, a modified MQ-1 Predator aircraft. USAF had previously rejected them, deferring to a flying culture bent on hands-on control of vehicles at all costs—to its own detriment as the UAV pilot force suffered from retention problems owing, in part, to overworked operators.

The ATLS system eyed by the service is already under development for use by Customs and Border Protection MQ-9s and has "conducted over 200 takeoffs and landings" with General Atomics aircraft in testing, says J.R. Reid, manager for Air Force strategic development at that company.

The upgrade includes software and hardware changes to the aircraft, including installation of sturdier main landing gear (a retrofit for Block 1 but standard in Block 5 aircraft); a wheel speed sensor module; and a laser altimeter on the aircraft, he says.

The system functions for both takeoff and landing by using a series of waypoints programmed into the UAV's flight profile. These waypoints are also tied to speeds, so once the aircraft touches down—for example—ground waypoints command reduced speed. Aborts for both operations are included as preplanned options.

U.S. AIR FORCE/STAFF SGT. JAMES L. HARPER, JR.

Waypoints to guide the Reaper for automatic takeoff and landing can be tailored to accommodate geographical features such as mountains at various bases used by the MQ-9.

Reid says modifications are slated for completion to allow for Customs and Border Protection aircraft to use its ATLS by year-end. He says the company can go as fast or slow as the Air Force requires for its fielding plans.

Use of an ATLS is also viewed by Reid as a "safety enabler." UAV advocates say the systems are often more accurate and less susceptible to problems, leading to fewer accidents. Early in Predator's operational history, pilots experienced numerous "hard landings" resulting in costly repairs to landing gear and sensors. Eventually, the Air Force designed pilot interface cues to help with spatial orientation for takeoffs and landings.

The U.S. Navy has used an ATLS for its X-47B trials on an aircraft carrier. It was based on a GPS system that positioned the air vehicle relative to the carrier's coordinates. The system provided highly accurate and predictable results for arrested landings at varying sea states. Some Navy officials have suggested using it to land even manned aircraft, such as the Super Hornet, to ensure safety for pilots prone to exhaustion at the end of a mission, especially in bad weather or at night.

Along with the ATLS, James also announced new bonuses for pilots who stay in the UAV career field—$15,000 per year for up to nine years. The Air Force also plans to implement a compulsory year of UAV duty for newly graduated Air Force pilots before they are able to move on to a manned aircraft, she says. She is also requesting funding for more simulators and other tools to accelerate relief to the career field.

Leading-edge root extensions and reshaped fuselage strakes (below the canopy sill) were tested on Typhoon IPA7.

New Tricks

Aerodynamic mods improve Typhoon's agility

Bill Sweetman Washington

Flight tests of a Eurofighter Typhoon with a suite of aerodynamic modifications show they have measurably improved the fighter's subsonic agility, say engineers and pilots involved in the project. The alterations can be easily retrofitted to any Typhoon, it is claimed, and have been demonstrated to pilots from Typhoon partner nations. The Aerodynamic Modification Kit (AMK) is being considered as part of future improvement packages for the aircraft.

The AMK comprises small leading-edge root extensions (Lerx), new delta-shaped fuselage strakes that replace the existing rectangular "step" strakes beneath the canopy sills, and larger flaperons (13% inboard, 8% outboard) that provide more forward sweep to the wings' trailing edge. The primary function of the Lerxes and reshaped fuselage strakes is to make vortex flows more stable and predictable as the angle of attack (AoA) increases. The larger flaperons provide more roll authority and also counteract the larger nose-up pitching forces introduced by the Lerxes and strakes. "We already have the most unstable production aircraft in the world," one engineer says. "We don't need any more pitch-up."

No new surfaces are added and the existing structure and flaperon actuators can cope with the changes, Eurofighter says, so the main tasks for transition to production would be the design of series-type AMK components and definition of a retrofit process.

The effects of the AMK changes are dramatic, Eurofighter says. Operational AoA limits are increased by 45% and total lift by as much as 25%. The corner speed—defined as the lowest speed at which the aircraft can generate maximum g force, and hence the speed at which the aircraft achieves its highest turn rate and tightest radius—has been "significantly reduced," increasing maximum turn rate. The usable pitch rate is increased "by far," according to project test pilot Raffaele Beltrame, and roll rate by up to 100%. The largest improvements are at lower speeds, but performance and handling are also improved in the subsonic regime, and supersonic maneuverability—where the Typhoon is second only to the Lockheed Martin F-22—is unaffected.

Airbus Defense and Space funded the five-year AMK program because the company and its customers believe fighter agility is still crucial. "Beyond-visual-range (BVR) is not the only thing, nor is the helmet-mounted display (HMD). Airframe performance is still decisive and with electronic attack, BVR can easily end up in a close-combat scenario," says project chief engineer Robert Osterhuber, adding that nose authority—the ability to pitch and yaw the aircraft to put the adversary in the forward hemisphere—is still a key factor in using HMDs and high-off-boresight missiles.

Typhoon's maneuverability has always been competitive, engineers say, but like all aircraft it has physical limitations. With the fighter's "carefree handling"—the use of the fly-by-wire system to ensure that the pilot cannot cause the aircraft to depart control flight—the stable envelope is protected automatically.

At low speeds, limits on AoA, pitch rate and other parameters are often associated with vortices that form around the forebody and canard at high AoA, and which can cause severe lateral-directional instability if they develop or burst asymmetrically. Very small features toward the front of the aircraft can cause strong vortices.

The step strakes on Typhoon were designed to generate stable vortices, based on computational fluid dynamics (CFD) technology available then. "[T]oday we have much better tools," Osterhuber says, and CFD is better integrated with wind tunnel testing. (The AMK configuration underwent extensive testing by the German-Dutch DNW wind tunnel consortium, and in Calspan's transonic tunnel.) He also notes that, in the past few years, Airbus has improved the sharing of expertise and tools between its commercial and military divisions, including its work with government research institutions.

The result is that with minimal changes, the AMK makes the vortices more stable and predictable, so that they enhance lift and improve pitch response. Less flaperon movement is required for pitch control, so that more authority is available for roll: consequently the increase in roll rate. Beltrame, who has been flying the Typhoon since 2004, calls the improvement "astonishing . . . it was a completely different aircraft, and I can say that without implying that the standard aircraft is not good. The potential for nose-pointing and precise tracking is incredible."

The AMK modifications have not been flight-tested with air-to-ground weapons, but wind tunnel tests of heavy configurations were carried out with positive results, says Beltrame. More control power allows more flexibility in loading and release sequences, and better maneuverability, but he also expects that integration of new weapons and the certification of new combinations will be easier. "Deltas can be very complex in the subsonic regime. With the strakes, it's more predictable, and easier to create a CFD model."

Galleries *See more about aerodynamic modifications for aircraft from the Concorde to F-22:* **AviationWeek.com/VortexControl**

Stressful Sales

Multiple military operations, Rafale exports strain French air force

Amy Svitak Paris

For nearly a year, the French air force has been operating at a capacity not anticipated in the nation's current defense strategy, and at a tempo that must be maintained even as a sudden surge in Rafale exports stresses air personnel and platforms.

Already the service is feeling the strain of supporting a €5.2 billion ($5.7 billion) deal with Egypt, announced in February, for 24 Rafale combat jets. The contract calls for pulling six aircraft intended for France this year out of Dassault Aviation's production line. The first three were handed over to Cairo July 20, in time for an August celebration honoring the Suez Canal expansion.

Adding to the air force's burden is a 24-aircraft order from Qatar, announced in May. That deal, which includes an option for 12 additional fighters, necessitated the negotiation of a separate contract with the French air force to provide technical support over several years, directly affecting the service's operational budget. It is the first time such an arrangement has been made, and it places an additional strain on personnel and assets.

Egypt took delivery of three twin-seat Rafale combat jets flown to Cairo July 21 from the Dassault Aviation flight-test center at Istres, France.

The situation dictates that additional Rafale export orders cannot pilfer from among those intended for French forces, says Gen. Denis Mercier, outgoing chief of the French air force. In addition, future export customers will have to adapt to the service's capacity to absorb the extra support required to train foreign pilots and technicians.

"My fear is that other Rafale export contracts will require accelerated deliveries, which would imply again taking aircraft from those intended for the air force, when it is no longer possible," Mercier said in June. "The Qataris are asking us for an operational transfer of several years, and we are able to ensure it. But it will require about 200 personnel full time, and will cause a lot of strain on our staff for at least two years."

France currently has nearly 4,000 military personnel involved in exercises and operational missions on French territory and outside its borders. In addition to airmen supporting quarterly exercises of France's airborne nuclear deterrent, the nation is providing fire support and reconnaissance to operations in Iraq, Central African Republic, Mali and Burkina Faso, among other commitments. The air force is also conducting reconnaissance missions around Ukraine and will provide anti-air defense support to the Baltic countries next year.

"Optimizing our capacity is obviously very important, because without it we wouldn't be able to conduct these missions," Mercier says. "We are now trying to distribute all the air missions to even out the stress. We can, for example, train people outside special operations to help reduce the load on the special operations forces. Even if they're not dedicated to the operation, they can still participate in some form to distribute the workload."

In the meantime, air force personnel have been training Egyptian pilots and technicians in preparation for their Rafale purchase. Egypt's first six Rafales are coming directly from the Dassault assembly line, and the company has promised to step up production and deliver another six to the French air force by 2019, to replace an aging squadron of nuclear-capable Mirage 2000Ns.

While the Qatari contract does not call for Rafale jets to be delivered as promptly, Mercier says the service will need to provide mechanics, airmen and experts in electronic warfare and intelligence under a separate support agreement.

"With Egypt, this was integrated into the Dassault contract, with a relatively short basic training. In this context, the air force intervenes in some way by charging its services to Dassault Aviation," he says.

But with the Qatari air force effectively doubling its capacity, its support contract calls for "a lot more than a formality of training," Mercier says. "What we're discussing is a real partnership among our two air forces, and a training period that's going to stretch over several years in France, which will lead to a real transfer of operational knowledge to the Qataris."

FRANCOIS ROBINEAU/DASSAULT AVIATION

Mercier says this technical arrangement was negotiated under a separate contract outside the Rafale export agreement with Doha.

"The Qataris will pay us directly for training," he says, with the financing affecting the French air force's operating budget. "In 24 months, we need to be ready with spare parts and simulators, as this is all part of the technical arrangement that is the subject of a separate contract. It is the first time we have gone to this type of contract."

Meanwhile, he says other Rafale exports are in the pipeline, most notably to India. That nation has verbally committed to purchasing 36 aircraft directly from Paris, in lieu of a 126-aircraft deal that was signaled by New Delhi in 2012 but foundered on technology transfer and price.

In June, French Defense Minister Jean-Yves Le Drian said he expects to sign a contract with India within months. With a third Rafale export contract, the company could increase production "up to a rate of four aircraft per month," Dassault Aviation Chairman and CEO Eric Trappier told French lawmakers in June. "We also have a wide margin for maneuver since, if India signed a contract, we would still not rise to this rate. We are not worried about the order intake."

Maritime Matters

Companies use Air Tattoo to promote their maritime patrol capabilities

Tony Osborne **RAF Fairford, England**

GLENN WHEELER/HIGHCAMERA LTD./RIAT PHOTO TEAM

The Japan Maritime Self-Defense Force (JMSDF) hailed the international debut of the country's indigenous Kawasaki P-1 maritime patrol aircraft in mid-July as a sign of the ever-strengthening defense relationship between Japan and the U.K.

But there is no disguising a sales pitch. Senior U.K. Royal Air Force officers flown on a demonstration flight here at the Royal International Air Tattoo in mid-July were impressed by the P-1's capabilities. The question is whether the Japanese aircraft will be given a chance to compete if the British government releases a potential requirement for a new maritime patrol capability in the Strategic Defense and Security Review (SDSR) later this year.

Several major defense companies are lining up for the expected requirement. Boeing's P-8 Poseidon is the front-runner, but the company has also briefed defense officials on its Bombardier Challenger-based Maritime Surveillance Aircraft, which was on display at the show as well.

Airbus Defense and Space is pitching a maritime patrol version of its C295 twin turboprop airlifter, while L-3 Communications, Selex ES and Ultra Electronics are partnering on a radically modified Bombardier Q400 regional airliner. Lockheed Martin is planning to announce a U.K.-dedicated version of its SC-130J Sea Hercules using the mission system from the Royal Navy's Merlin Mk. 2 helicopter and the airframes of C-130J airlifters that are active now but due to be withdrawn from service by 2022.

The Kawasaki P-1 option comes out of left field. The aircraft is one of the first maritime patrol aircraft to be developed since Dassault's 1960s-era Atlantique family; the rest are conversions of airliners or transport aircraft.

The four-engine jet has been designed to maintain the Japanese antisubmarine warfare and maritime patrol doctrines it developed with the P-3 Orion, but flying higher and faster—with improved sensors. Four engines mean that two can be shut down in the cruise mode, extending endurance. The large nose allows for fitment of an active, electronically scanned array radar. The front fuselage features retractable electro-optical cameras and a weapons bay for torpedoes. The P-1 has a sonobuoy launch system in the rear fuselage behind the wing-box and a magnetic anomaly detector behind the tail.

"We have put emphasis on visual identification," Vice Admiral Makoto Sato, commander of the JMSDF's aviation fleet, said at the Air Tattoo. The aircraft is still in development but should reach operational capability this September, he said. Several P-1s are already with operational squadrons.

"The aircraft is quiet, responsive and very comfortable operating at low-level," says one of the RAF officers who flew on the demonstration flight.

"Like on the Nimrod, they can shut two engines to save fuel, something you can't do on the Poseidon," notes another RAF official.

Much now depends on whether the U.K. opts for the multimission aircraft or simply a maritime patrol aircraft with the ability to conduct overland surveillance. Recent images indicate that the P-8 is capable of taking several different under-fuselage sensors aloft.

The road map for the P-1 is less clear. Sato says the JMSDF plans to conduct upgrades every two years, and these will include advanced weaponry beyond Harpoon and Maverick missiles, torpedoes and mines.

The Kawasaki P-1 led a lineup of maritime patrol aircraft on display at the 2015 Royal International Air Tattoo.

While the upgrades are a step forward, they might not provide the multimission capability that may be sought by the U.K. The JMSDF has 10 P-1s in service and 20 P-1s on order out to 2020 but will need around 70 to replace the P-3 Orion fleet that also includes specialist variants, including the electronic intelligence EP-3s and optical reconnaissance OP-3s. It is not clear whether these will be replaced by modified P-1s.

A U.K. evaluation of the P-1 could provide Japanese industry with helpful exposure to overseas defense procurement processes now that Japan's strict rules on defense exports have been loosened.

But many signs still point to a British purchase of the P-8 Poseidon. The majority—20 out of 30—of the aircrew selected for the Seedcorn initiative to maintain maritime patrol skills are flying on U.S. Navy P-8s. The Seedcorn program has conducts been given a three-year extension as Boeing has conducted studies of a number of U.K. airbases where the type could be stationed. Lossiemouth in Scotland and Waddington in northeast England are two contenders.

The P-1s flew from Fairford AB to Sigonella AB in Sicily before heading for Djibouti, where they and their sensitive electronics were subjected to extreme heat and dusty conditions as part of operational testing. With the JMSDF in Djibouti supporting anti-piracy operations in the Indian Ocean, the P-1s could be making regular visits to Africa as more aircraft enter service.

Gallery *See aircraft highlights from this year's Royal International Air Tattoo at RAF Fairford, England:* **AviationWeek.com/RIAT2015**

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Fuji's Future

Japan opts for twin-engine Huey as its new utility helicopter

Bradley Perrett Beijing

Fuji Heavy Industries (FHI) has secured its formerly doubtful future as a helicopter builder by winning a competition to supply a utility helicopter for the Japanese army in partnership with Bell. In choosing FHI and the well-established Bell 412 for the army UH-X program over a Kawasaki Heavy Industries (KHI) offer, the defense ministry has minimized spending and risk in development. KHI proposed the Airbus H160, which is still being developed. AgustaWestland also made a bid.

Full-scale development is due to begin this year, with production of 150 aircraft at an average rate of 7.5 a year from 2021, not counting a planned civil version. Production cost is estimated at ¥1.2 billion ($8.1 million) per helicopter.

BELL HELICOPTER CONCEPT

The ministry's decision means that the 412 will be in production at least until 2041, which will be 85 years after the first flight of the UH-1 Iroquois from which it is derived. And the choice of FHI sustains the fragmentation of Japan's rotorcraft industry, with three manufacturers supplying the limited local market.

The civil version of the army UH-X is intended to augment the low volumes that come with fragmented production. It will come first, with the military aircraft based on it, FHI tells Aviation Week. The company expects civil sales mostly in Japan. South Korea, Korea Aerospace Industries and Airbus will follow the same pattern in the proposed development of the Light Civil Helicopter (LCH) from the Airbus H155 and the Light Armed Helicopter from the LCH.

The total development cost for the army UH-X will be only ¥13.3 billion, of which the defense ministry will pay only part. The total, including contributions from FHI and Bell, is barely half as much as the ministry previously proposed spending on development, ¥23-26.3 billion. That figure, mentioned as recently as late last year, would have been enough to pay for extensive military modification of the H160.

With so little due to be spent on army UH-X development, FHI confirms that the 412 will not be greatly modified. The company declines to give details, but the Pratt & Whitney Canada PT6T powerplant, at a minimum, would surely have to be retained. The UH-X will be based on the latest U.S. version, the 412EPI. The type probably had an advantage in its roots as a military aircraft; it is a twin-engine variant of the original single-engine UH-1 series, known as the Huey, which FHI was building as the UH-1J until late last decade. In influencing the competition, the army put a high priority on having a robust, genuinely military helicopter, say industry sources.

KHI and Airbus were widely regarded as the favorites earlier this year. Airbus had raised the possibility of making KHI a production partner in the whole H160 program. The European and Japanese manufacturers discussed KHI building the drive train and rotor for all H160s. International collaboration instead of license production is just the sort of efficiency-enhancing arrangement that Japan's newly relaxed policy on arms exports is supposed to promote. But in the end, in this case, the defense ministry saw reasons for sticking to the old way of doing things.

FHI's experience in building single-engine UH-1s and its long partnership with Bell will help reduce risk and cost. The ministry says the FHI proposal was superior to KHI's in six out of seven categories, including the feasibility of development and the time at which deliveries could begin. Another industry official says that the foremost advantage was cost.

Bell emphasizes similar themes. As a UH-1J replacement, the 412 will be "cost-effective, capable, and reliable," presenting "the lowest amount of risk to cost and delivery schedule," the company says.

As early as 2009, Fuji Heavy Industries proposed the Bell 412 to replace the UH-1J.

A key mission for the army UH-X will be for a response to an attack on remote islands, presumably meaning the Senkakus, which China claims under the name Diaoyu Islands. For this, the army needed the reliability of two engines. The PT6T, with the military designation T400, consists of two PT6s driving a single gearbox. Other army UH-X roles include response to a commando or guerrilla attack. The type will also be used for disaster relief and peacekeeping.

Since FHI has not received an order for the UH-1J since 2007 and has no other prospective helicopter program, it needed to win the army UH-X contract to stay in the rotorcraft business. A utility helicopter program for the navy, confusingly also called UH-X, is unrelated. The contenders for that competition are KHI and Mitsubishi Heavy Industries, Japan's third helicopter maker.

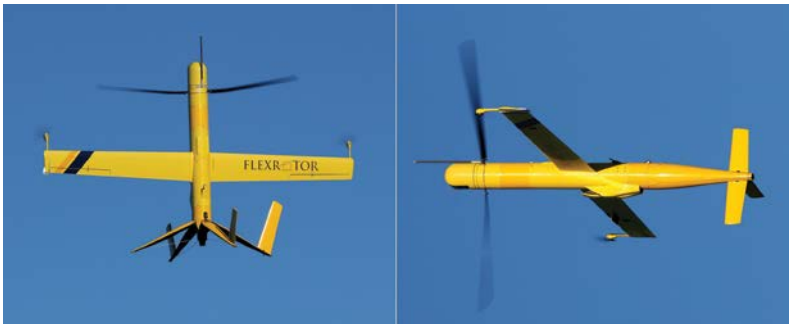
Preparation for the army UHX program began at least as early as last decade. The ministry chose KHI in 2012 to develop an all-new rotorcraft but then canceled the decision, accusing the company of violating a law against bid rigging. KHI notes that it was not prosecuted.

Separately, the U.S. Navy has contracted Bell and Boeing to build five V-22 Ospreys for Japan, which has ordered the type as the first export customer. The contract includes support, training, and equipment. Current Japanese planning calls for 17 of the tiltrotor aircraft, though Bell has said that Tokyo may eventually buy more.

Deck Mate

Long endurance from small ships for civil missions is here

Graham Warwick Washington



AEROVEL

The unmanned-aircraft team behind the Atlantic-crossing Aerosonde and tuna-finding SeaScan is putting finishing touches to the production configuration for its latest and most challenging design. The Aerovel Flexrotor is a 45-lb. UAV designed to fly more than 40 hr. but able to take off and land vertically on the helideck of a small ship.

White Salmon, Washington-based Aerovel recently completed sea trials with two preproduction Flexrotors. The UAVs operated from the expedition yacht Umbra in Costa Rica's Cocos Island National Park, supporting efforts by the Dalio Foundation to curb illegal fishing.

Aerovel was founded in 2006 by Tad McGeer and others from Insitu, where they had designed the Aerosonde, SeaScan and its military development the ScanEagle. Insitu, acquired by Boeing in 2008, was getting into the military business and McGeer wanted to pursue the civil market.

The result was the Flexrotor, a tailsitting vertical-takeoff-and-landing (VTOL) unmanned aircraft with a 9.8-ft.-span fixed wing and 6.1-ft.-dia. two-blade rotor. It takes off like a helicopter then transitions to wingborne flight, the rotor becoming a propeller, then converts back for vertical landing.

Arethusa launches from the Umbra at anchor in Chatham Bay off Cocos Island.

Small folding-propeller thrusters provide roll control in rotorborne flight. In a recent design change, the faired tail now opens up to form four landing legs. Propulsion is provided by a two-stroke piston engine burning automotive gasoline. Range at the 46-kt. endurance speed is more than 1,800 nm.

The Cocos trials were operated by Flexrotor launch customer Precision Integrated Programs, which flies aircraft for the Dalio Foundation. Formed by philanthropist Ray Dalio, billionaire founder of hedge fund Bridgewater Associates, the foundation owns the expedition vessels Alucia and Umbra and also supports the Woods Hole Oceanographic Institution.

The weeklong trials in May involved day and night flights of preproduction Flexrotors Arethusa and Calypso from Umbra's helideck. The 51-meter (167-ft.) superyacht was at anchor for all but one of the flights. Tests included spotting a bulk carrier detected by Umbra's automatic identification system.

"Over the summer we will finish the production design for the Mk 1. This has a larger fuel capacity and different electrical system," says McGeer. "Next year, we will move to the Mk 2, which will have an avionics update and a little bit more fuel. As we shrink the avionics we have more room for fuel."

This second-generation aircraft will enable Aerovel to meet its original design goal for the Flexrotor of two days' endurance carrying a 3.3-lb. daylight-imaging payload, he says.

The Flexrotor carries an Alticam Vision daylight video camera in a stabilized nose turret. McGeer says Aerovel has received requests to carry Hood Tech Vision's midwave infrared sensor. "That's more than Flexrotor is designed for, so we would need to increase gross weight and have a larger diameter rotor."

Flexrotor in rotorborne vertical flight (left) and wingborne horizontal flight (right).

The design can be scaled up. "We will see what develops in payloads. There is lots of ability to make a bigger aircraft," he says. Aerovel proposed a 2-ton aircraft with a 15-meter span for Darpa's Tern ship-based UAV program. "We called it the 2-ton Tern, but it was still a Flexrotor."

Initially, the company is aiming the Flexrotor at sea-based applications including tuna hunting, marine expeditions, environmental monitoring and even spotting icebergs for cruise ships venturing to high latitudes. Other possible uses are wildlife preservation, disaster relief and homeland security.

Insitu's SeaScan, which like the ScanEagle was launched by catapult and recovered by capturing it from a suspended wire, was designed for operation from fishing vessels. "There is a long-standing need to replace helicopters on tuna boats because of their expense and safety record," says McGeer.

IAN KELLETT/ALUCIA PRODUCTIONS

"People in the tuna business are lining up, but there are other customers interested, and it's not clear who will go first," he says. "We will be running hard to satisfy everybody over the next year." Flexrotor development has largely been funded internally, with support from Darpa and the Office of Naval Research, but Aerovel is looking at raising capital "so we can do more, faster," he says.

Most of the interest in the Flexrotor, which has a price tag of $200,000, is coming from outside the U.S. "It's the reality of economics," McGeer says. "Where there is plenty of general aviation [such as in the U.S.], the economics of an unmanned aircraft [versus manned] are not so compelling. We hope to make them compelling."

Integrated Innovation

Propulsive efficiency is Turbomeca focus in next phase of Clean Sky

Guy Norris Paris

Safran company Turbomeca has unveiled new details of its plans to test a more fuel-efficient turboprop for small regional transports and business aircraft, even as Rolls-Royce and Snecma continue preparations for large-scale turbofan and open-rotor engine demonstrations under the €4 billion ($4.4 billion) next phase of Europe's Clean Sky research program.

"Although Clean Sky 1 is aimed at improving current engines and launching new core technologies to reduce specific fuel consumption, Clean Sky 2 for us is about improving propulsive efficiency," says Turbomeca Clean Sky lead Brigitte Cheftel-Py. "In Clean Sky 1 we worked on core engine components and architectures to push the thermodynamic cycle of the engine, but another way to gain fuel improvement is to optimize engine integration on the platform, which is what we intend to do on Clean Sky 2 in the turboprop application."

Under the initial €1.6 billion phase of Clean Sky, a public-private partnership in which European Union research funding was matched by industry and other participants, Turbomeca developed and tested a 1,000-1,200-shp turboshaft. Compressor, turbine and combustor elements from the demonstrator, known as Tech800, were rolled into the Arrano engine, which will exclusively power the newly developed Airbus Helicopters' H160.

Cheftel-Py says the "final configuration [of Tech800] at high turbine entry temperature was successfully tested in mid-2013, and the program is approaching completion, which will be at the end of 2015."

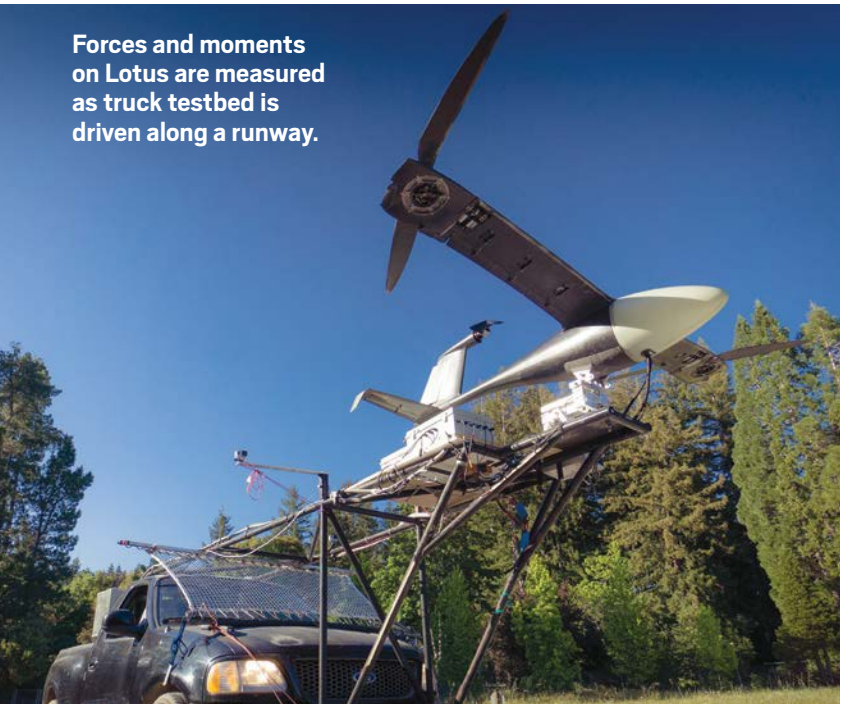
Under Clean Sky 2 "the main objective is to design and develop a new 1,800-2,000-shp turboprop engine for business aviation and short-range regional aircraft using the Ardiden 3 [turboshaft] as the core," she adds. "We are going to develop technologies to integrate the core with the features of a turboprop, so that means we will work on an advanced propeller, gearbox and inlet, as well as controls, lubrication and actuation systems. The aim is to reduce the weight of the gearbox and to develop a smarter and more efficient air inlet and propeller system to get the best integrated operation. This way, we hope to find more ways to reduce specific fuel consumption.

"We are also going to work on technologies for the high-pressure core to reduce its size by increasing the pressure ratio, as well as work on the combustor to reduce emis-

A Different Tilt

NASA collaboration gives startup company head start in electric VTOL

Graham Warwick Dallas



Forces and moments on Lotus are measured as truck testbed is driven along a runway.

JOBY AVIATION PHOTOS

A vertical-takeoff-and-landing (VTOL) unmanned aircraft with rotors that stop and fold to become wingtip extensions, improving cruise efficiency, is entering ground testing at startup Joby Aviation.

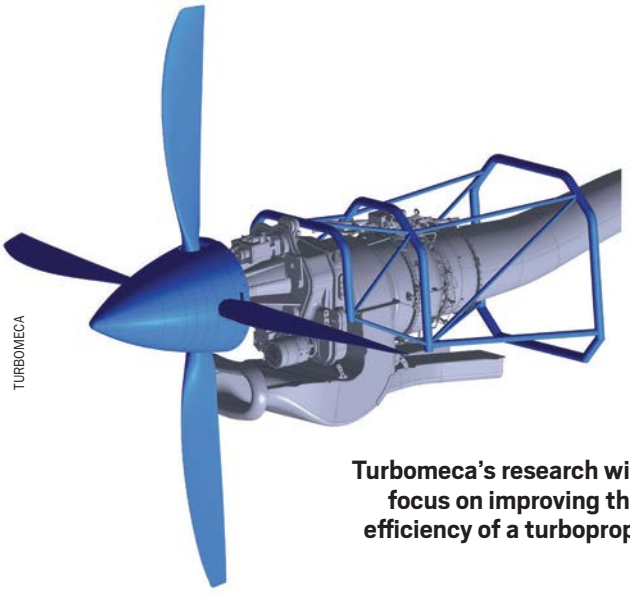
The Lotus is a 55-lb. UAV that pioneers the "multifunctional reconfigurable propeller" concept developed by Santa Cruz, California-based Joby from a NASA design study for cruise-efficient VTOL.

NASA's Dos Samara concept had single-blade rotors mounted on the wingtips that stopped to form wingtip extensions in forward flight, extending span and reducing cruise drag. But this resulted in low rotor efficiency and high cyclic loading at the pivots, while the counterweights compromised aerodynamics.

Joby developed a rotor with two blades that scissor together to form parallel wingtip extensions. This improves efficiency and reduces cyclic loading. Additionally, unlike in other stopped-rotor designs where a blade ends up backwards, the leading edges face the airflow in both vertical and horizontal flight.

The rotors are driven directly by brushless electric motors integrated into the wingtips. Forward and aft blades have the same airfoil, chord and twist distribution from tip to near the root, but are attached at different dihedral angles to increase rotor clearance, Pranay Sinha, an engineer at sister company Transition Robotics, told the AIAA Aviation 2015 forum in Dallas in June.

In VTOL mode, the rotors spin at a low, 35-fps tip speed, he says. A third propeller, projecting forward from the tip of the vertical fin, tilts up-



TURBOMECA

Turbomeca's research will focus on improving the efficiency of a turboprop.

sions," says Cheftel-Py. The company also plans to evaluate the potential to hybridize the core by adding electric power.

"We [intend] to perform a preliminary design review at the end of the year, so we are studying different configurations to determine which technologies will be demonstrated in Clean Sky 2," she says. Detail design will take place over 2016 with a critical design review targeted for late that year. Manufacturing of initial components is set to start in the fourth quarter of 2016, with buildup and testing of the initial rig elements slated for 2018-19. "All testing will be performed on the ground only, as there are no flight tests planned for the moment," says Cheftel-Py.

The Clean Sky 2 project, although aimed at the small-to-medium power range, is also expected to underpin Safran's broader ambitions to develop a larger advanced turboprop for regional prop-driven airliners. First unveiled by Snecma in 2013, this is targeted at an engine in the 5,000-shp power sector, far larger than any previous Turbomeca turboprop. Although the project is thought to have slowed—in line with the apparent reluctance of the main turboprop airframe manufacturers, ATR and Bombardier, to commit to a larger new aircraft—the engine, if launched, would compete head-on with project turboprops already outlined by Pratt & Whitney Canada and General Electric.

Under Clean Sky, the Green Regional Aircraft project is developing aerodynamic, structural and systems technologies that could be applied to a new 90-seat turboprop, which is in planning at ATR but not yet approved by partners Airbus and Alenia Aermacchi. The technologies are focused on reducing weight, noise and emissions. An ATR 72 testbed is now flying with a multifunctional composite fuselage panel with embedded structural health monitoring. Other testbeds are evaluating more-electric systems, including power management and distribution, and electrical environmental control and deicing systems.

ward to provide balancing thrust. In vertical flight, control in pitch is provided by differential wing and tail motor rpm (and so thrust), in roll by differential wing thrust, and in yaw by differentially tilting the wingtips forward or aft.

To transition, the fintip propeller tilts down and the wingtips tilt forward to accelerate the aircraft into wingborne flight. The rotor blades then scissor together to form the split wingtips.

The Lotus has been pursued in parallel with NASA Langley Research Center's Greased Lightning GL-10 distributed electric propulsion VTOL UAV, which has 10 props mounted on its tilting wing and tail. GL-10 and Lotus have been developed to show different approaches to achieving cruise-efficient VTOL.

Joby has developed its design over seven prototypes, culminating in the 55-lb. vehicle now in ground test. Design changes include increasing the rotor diameter to 4.2 ft., slowing rpm, growing disk area and reducing the power requirement in vertical flight.

The tail has evolved through several design iterations to where the vertical fin is now swept forward and the prop rotor is mounted forward of the tip to minimize download on the horizontal tail in the hover.

As it prepares for flight tests, Joby has mounted the Lotus on a Ford F-150 truck to conduct dynamic ground testing. This mobile testbed allows data on forces and moments on the aircraft to be gathered as the truck is driven along a runway, says Sinha.

While it works on the Lotus, Joby is also pursuing development of its first commercial product, the S4 four-seat civil tiltrotor. This uses distributed electric propulsion, with multiple propellers on the wing and tail, which tilt up for vertical flight and fold away in cruise flight.

Full-size 55-lb. UAV prototype shows multifunction wingtip surfaces in their two modes.

The original plan was to develop the two-seat S2, which had eight tilt/fold props on the wing and four on the tail, plus cruise propellers on the tips of the wing and tail. The S4 is likely to have six larger props.

The aircraft will cruise at 200 mph compared with 135 mph for a Robinson R44 four-seat helicopter, says Alex Stoll, an engineer at Joby. Energy usage for the electric-powered S4 will be four times lower based on trip time and 6-7 times based on distance flown, he says.

One of Joby's design goals is to eliminate failure mechanisms to improve safety. Distributed electric propulsion is simpler than a helicopter rotor system and provides redundancy, he says, adding, "We tilt the motors not the wing because wing tilt is a single point of failure."

New Horizons

In with the old as well as the new at Oshkosh

The Airbus A350 XWB, on arrival at Oshkosh, flew the American flag to celebrate both the U.S. airlines that have bought the aircraft and the American content in every Airbus airliner.

John Morris, Molly McMillin, Fred George and John Croft Oshkosh, Wisconsin

It is telling that the Experimental Aircraft Association's Innovation Center at this year's AirVenture show, a feature added several years ago to showcase emerging technologies related to general aviation, was largely filled with manufacturers or retailers of drones; at least three of the more than a dozen in attendance hailed from China. Attached to the Innovation Center was a fenced yard, or Drone Cage, where attendees could take the compact, battery-powered quadcopters out for a test drive.

Jack Pelton, Experimental Aircraft Association (EAA) chairman, was planning to open the show with a ribbon cutting on July 20 using a pair of scissors delivered to him by quadcopter, but it was too windy for accurate flying and the drone hovered in camera mode for the event instead.

A clutch of caged drones, a multitude of airframers and suppliers, the towering presence of the Airbus A350 (the second flight-test aircraft) and the excitement of the first civilian air show appearance for the Lockheed Martin F-35 Lightning II, underscored the growing sphere of the EAA's influence. And while multibillion-dollar aircraft purchase announcements are not standard fare for the event, much business does get accomplished and new products do come to light.

One of the latter is a single-engine turboprop to be built by Textron Aviation, which counts Cessna and Beechcraft among its subsidiaries. "We plan to have something to show people next year at this time," says Michael Thacker, Textron Aviation senior vice president for engineering. The company has been talking with operators to understand the needs, and a newly dedicated team was assembled to develop the turboprop, to be designed for a 1,500-nm range and cruise speed of more than 280 kt. The former Hawker Beechcraft had a product development plan in 2012 that included the concept for a family of single-engine turboprops, and the company had been gathering feedback from the customer base. Financing, however, kept the program from progressing past the drawing board.

When choosing an engine for the new turboprop, Textron will likely turn to a source with deep turbine engine heritage—General Electric. Brad Mottier, GE's vice president and general manager of business and general aviation (BGA) and integrated systems operation, says the company is defining a next-generation, clean-sheet, 2,000 shp-class general aviation engine that will compete against top-end Pratt & Whitney Canada (PWC) PT6As that power Pilatus PC-12, Daher Socata TBM900 and Textron Beech King Air 250 and 350, among other high-performance single- and twin-turboprop general aviation aircraft. PWC has been the sole provider of turboprop engines in this power class for more than three decades.

"We're going to use 'Big GE' technology and scale it down," says Mottier. GE's Dowty division now reports to BGA, and Mottier intends to make full use of its advanced propeller technologies, well refined for regional turboprops, along with its 3-D integration of prop, nacelle, wing and fuselage aerodynamics, to develop general aviation turboprop engines with clearly superior thrust, fuel efficiency and emissions characteristics, as well as reduced noise, harshness and vibration. For use on the new engine, BGA is evaluating single-

Up to 10,000 aircraft flocked to Oshkosh, Wisconsin, for EAA AirVenture, making it the biggest aviation event in the world.

ALL PHOTOS BY MO SPUHLER

The nighttime aerobatic display lit up the sky. The Aeroshell team of four T-6 trainers flew in tight formation, with their engine cowls illuminated and smoke trailing from tail-mounted flares.

channel digital electronic engine controls and dual-channel full-authority digital engine controls, variable stator vanes, advanced ceramic matrix composites and active clearance control. Mottier has at his disposal the depth and breadth of GE Aviation's research and development capabilities.

Airframers Piper Aircraft and Epic Aircraft at the show reported that their turboprop programs, the M600 and the Epic E1000, respectively are coming to fruition. Piper is expected to complete the certification for its M600, a higher-performance version of the single-engine Meridian turboprop, in the fall. Despite an order for 26 new single-engine training aircraft for the FlightSafety Academy, which was announced at the show, the company says it still plans to cut its workforce of 750 employees by 15-20% due to sluggish sales and economic instability in some of its markets.

Epic, which is owned by Russian firm Engineering LLC, says its six-seat carbon-fiber aircraft is on schedule for FAA type certification in the first half of 2016, and that funding is in place to cover both the type and production certification. The company plans to hire more employees for the work, growing its ranks to 200 from 185 in early 2016. Epic had previously anticipated gaining certification by the end of 2015.

Cirrus is also hiring and is expanding its facilities in preparation for an expected certification of the Vision SF50 personal jet by year-end. The company is phasing in a new manufacturing platform called the electronic manufacturing execution system to take advantage of the benefits of robotics as it builds the jet.

"Green" announcements at the show included a new program by aviation services company Yingling Aviation, to remanufacture older Cessna 172/182/210s as well as Piper PA28 Archers and Cherokees and Beech Bonanzas. Initially the company will focus on the 172N model that will be remade into the $160,000 Ascend 172. The remanufacture will include corrosion inspections, engine and interior overhauls, panel upgrades and painting.

AirVenture continued to highlight the less-than-stellar safety record of general aviation. Early in the week there were two relatively minor incidents—a nose gear collapse and a gear-up landing—but a serious accident occurred on July 22 when a single-engine Piper Malibu crashed on short final. Of the five passengers, one was taken to the hospital via a medevac helicopter.

NTSB Chairman Christopher Hart, speaking to Aviation Week earlier in the week, noted that while the fatal accident rate for general aviation has been "more or less flat" for the past few years, the rate for business aviation has been going down, meaning the rate for personal aviation is doing the opposite. "That's what concerns us," he said. "How do we get our hands around personal flying getting worse?"

Among the various causes of fatal accidents, loss of control (LOC) is the most dominant, at fault in more than 40% of accidents, says Hart. The NTSB is planning a deep dive on LOC on Oct. 14 in Washington to discuss the causes and possible interventions, possibly resulting in recommendations to the FAA or other parties.

Preventing stalls would be a good start to fixing the problem, as LOC generally progresses from an aerodynamic stall. "One way to do that is more training; another is with angle-of-attack (AOA) indicators," says Hart. AOA systems were a

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The F-35 made its first civilian air show appearance at EAA AirVenture, with the U.S. Air Force bringing two F35As from Eglin AFB, Florida.

China's city of Shenzhen is known as the world's center for the manufacture of cellphones. Drones will be next, says Nicky Wan (above), sales manager for drone manufacturer Shenzhen Jiuxing Tianli Technology Co., which was exhibiting its latest models at the show. The EAA Innovation Center for the first time featured a Drone Cage that allowed a variety of unmanned vehicles to be safely demonstrated (inset).

hot topic at last year's show, with Bendix King launching a low-cost device called the KLR10. The systems have a visual and often an audio indicator to alert the pilot when the AOA is approaching the stall, a condition that can occur at any airspeed.

"The take-up is great around air shows," says Bendix King's new president, Justin Ryan, a former naval aviator, but he notes that sales slow outside of shows like AirVenture. As a Navy pilot, Ryan flew by reference to AOA along with other instruments. "We haven't yet found the magic formula to keep [pilots] interested all the time."

Hart addressed drone safety as well, noting that all "dozen or so" drone accidents the NTSB has investigated have been single-vehicle incidents. "We're hoping not to ever see a two-vehicle where the engine ingests one of these," says Hart. "It is one thing for the engine to ingest a Canada goose and another thing to ingest a drone." He gave credit to EAA for its part in helping to spread a safety message to drone operators who in many cases might not "have a clue" they're operating in airspace where they should not be.

Pelton says EAA has no choice but to embrace the burgeoning market. "Between the commercial use of drones and business-based photography there is a space for recreational use," says Pelton, adding that the EAA must be involved with the emerging industry to have a say in protecting airspace and keeping up on developments. "There will be many innovations," and that fits exactly into the spirit of EAA, Pelton says.

Back to the future: Yingling Aviation plans to remanufacture old Cessna 172Ns and offer them as-new for a base price of $160,000. It could expand the remanufacturing program to other aircraft, such as the Cessna 182, Piper Archer and Cherokee and Beech Bonanza.

Aviation Week's Fred George, chief aircraft evaluation editor, waved as he tested the ICON A5 amphibian at Oshkosh. Delivery of the first production aircraft was made at the show, to the EAA Young Eagles organization.

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Airline Factory

Perhaps because new airlines promote economic growth, the CAAC is approving a lot of them

Bradley Perrett Beijing

YBEN/AIRLINERS.NET

China's economy may be slowing, but the country's flood of new airlines is hardly abating. Over the past year seven carriers have begun flying or have started the regulatory process for doing so. Carrier after carrier has had backing from city or provincial governments, extending a trend that first reemerged in 2009, less than a decade after the government ended the previous wave of airline proliferation by forcibly merging most.

Reflecting their official backing, all but two of the airlines that have emerged over the past year are full-service carriers, even though the Civil Aviation Administration of China (CAAC), previously unenthusiastic about low-cost airlines, began encouraging their formation in 2013. No-frills operation may be an excellent submarket for a new airline faced with mighty, entrenched competitors, but it lacks that essential Chinese characteristic of face, or prestige. Clearly, local governments are far more willing to pay for an airline if it offers full service.

Usually, but not always, a well-established airline is also a shareholder, giving the local government confidence that operations will be expert and reassuring the CAAC that safety standards can be easily achieved. And whereas the central government's big carriers—China Southern Airlines, Air China and China Eastern Airlines—have tried their hand at setting up new carriers since 2009, over the past year privately owned airlines have been at the fore. Predictably, hyperactive HNA Group, owner of Hainan Airlines, Tianjin Airlines and other carriers, turns up time after time in these developments.

Another typical characteristic is a decision to start operations with a handful of Airbus A320-family or, most likely, Boeing 737 aircraft, with an aim to operate some 10s of them in a few years. Like budget operations, regional aircraft may make more sense but are not preferred. The governments must help create the airlines and subsidize operations, because the market will not support the planned services. Smaller aircraft have lower trip costs so need lower subsidies on passenger-scarce routes. But standard narrowbodies are not only more prestigious; their pilots and technicians are far easier to find in China, where aviation skills are in chronic short supply.

The CAAC is at least as careful on safety as other civil aviation authorities, which is why it clamped down on new airlines until 2013. No reasons are given for its decision to approve so many since then, but additional airlines will likely spur economic growth, which has eased from annual rates of 10% or more for the three decades after 1978 to around 7% now. Whatever the motivation, China has become something of an airline factory, with new carriers proposed every few weeks.

A good example of the latest crop is Jiangxi Airlines, which aims at operating 30 aircraft by 2020, with an initial target of five this year. CAAC has authorized the establishment of the airline company but has not issued an air operator's certificate. The owners of Jiangxi Airlines are Xiamen Air, with 60% of the equity, and Jiangxi Aviation Investment Co., Ltd., an arm of the government of Jiangxi, a southern province.

GX Airlines is one of only a few new carriers in China that opted to fly large regional jets such as the Embraer 190.

Consistently profitable Xiamen Air is itself majority-owned by China Southern but works closely with its other shareholder, the government of the eponymous city. It is happy to be paid to do the government's bidding, and, apparently for that reason, has bought a modest fleet of Boeing 787-8s (*AW&ST* Sept. 8, 2014, p. 39).

Typical of airlines backed by provinces or cities, Jiangxi Airlines will be based at an airport that is operating well below its designed capacity. The base is Nanchang Changbei Airport, which was designed for 15 million passengers a year but last year handled only 7.25 million. Jiangxi is not well served by the country's fast rail network, adding to the keenness of the authorities to back a local airline.

Xiamen Air will supply 737s for initial operations; five should be in service by year-end. The type intended for the fleet of 30 in 2020 is not disclosed. Priority destination cities are Beijing, Shanghai, Guangzhou, Shenzhen and Chengdu, but the authorities say the carrier will later link Nanchang with Singapore, Thailand, Malaysia, Japan and South Korea.

The latest Hainan Airlines subsidiary to begin flying is GX Airlines, based in the southern province Guangxi. Exceptionally, it is a regional jet operator, equipped with Embraer 190s—one of which was tapped for the first flight on Feb. 13 from the provincial capital, Nanning, to Haikou on the island province Hainan, just 380 km (236 mi.) away. GX will probably receive aircraft from a Tianjin Airlines order for 20 current-series E Jets and 20 of the E2 series that was announced in July 2014.

GX aims at operating 10 190s by the end of 2015, by which time it should be flying at least two routes to Southeast Asia, says the provincial government. So quick a move into international operations is unusual. Nanning Wuxu airport will be the carrier's base. Haikou is the home of Hainan Airlines.

CAAC gave preliminary approval to the establishment of GX in June 2014 under its Chinese name, Beibu Wan Airlines. Beibu Wan is the Mandarin name of the Gulf of Tonkin, on which Guangxi has a coast. GX evidently stands for Guangxi.

In June, HNA Group agreed to set up a carrier with the eastern city Ningbo. It will be called Ningbo Airlines; the government that pays the bills usually expects the business to be named after the locality. Moreover, the company is seen as a trading division of the government, so "Ningbo Airlines" is as natural a name as "Ningbo Education Department."

The fleet target is 16-20 aircraft by 2020, municipal media report. HNA has also agreed to work with Ningbo in promoting airport development, logistics, aircraft maintenance and general aviation, including business aviation. Such wide-ranging ambitions are common when Chinese local govern-

ments sign such framework agreements, and they are often unrealized. But setting up an airline is usually quite achievable; an operational start date has not been announced.

China Eastern and China Southern are the main operators at Ningbo Lishe International Airport and therefore have the most to lose from a subsidized competitor. In October 2014, another HNA-government partnership airline, Fuzhou Airlines, began flying at Fuzhou, just down the coast from Ningbo.

Fuzhou and Ningbo are well-developed cities. The parts of the country that are lagging in economic development, such as Guangxi, have the greatest incentive to subsidize an airline. The northeastern province Jilin is a middling position and has a remote hope of setting up an airline this year. Jilin is also trying to attract budget carriers and open services to Southeast Asia, says the state-owned group that runs the province's airports. The carrier would presumably be based at Changchun Longjia International Airport.

No partner airlines have been announced, but the province should be in negotiations with at least one. China Southern is the only airline with a base at Changchun, so it would have the most to lose from a new carrier opening for business there, unless that company were a China Southern subsidiary.

The provincial government says it is trying to arrange new air services linking Changchun with Singapore and Bangkok, while also increasing frequencies to Phuket, Thailand. These sites are key holiday destinations for Chinese. Low-cost airlines will be attracted at an appropriate time, says the government. Their arrival would alleviate the problem of Changchun Longjia having low service density and high fares, it adds.

Out of the mainstream of new Chinese airlines is Colorful Guizhou Airlines, the name of which has perhaps lost something in translation. Like Guangxi, Guizhou is not well-developed, which explains why the Embraer 190 was chosen as the type to begin operations with, hopefully this year. And Guizhou's officials are heeding the CAAC's call for budget operations, so Colorful will be a no-frills carrier for the time being.

China's Newest Airlines

Name	Status	First Flight	Affiliate Airline	Base	Initial Aircraft Type	Fleet Target
Fuzhou Ailrines	Operating	Oct. 2014	Hainan Airlines	Fuzhou	Boeing 737-800	40 by 2020
9 Air	Operating	Dec. 2014	Juneyao Airlines	Zhanjiang	Boeing 737-800	Intends to order 50 Boeing 737s
GX Airlines	Operating	Feb. 2015	Tianjin Airlines	Nanning	Embraer 190	10 Embraer 190s by end of 2015
Ningxia Cargo Airlines	AOC issued	Unknown	None	Yinchuan	Boeing 737-300F	None stated
Colorful Guizhou Airlines	Established*	Late 2015 maybe	None	Guiyang	Embraer 190	30 by 2020, 120-140 later
Jiangxi Airlines	Established*	2015 planned	Xiamen Airlines	Nanchang	Boeing 737	30 by 2020
YT Express	Application lodged	Subject to CAAC	None	Hangzhou	Boeing 737-300F	None stated
Ningbo Airlines	Proposed	Unknown	Hainan Airlines***	Ningbo	Unknown	16-20 in 2020
Northeast Airlines**	Proposed	Unknown	None announced	Shenyang	Probably Boeing 737	5 Boeing 737s, 20 Xian MA600s by 2020
Jilin Airlines**	Proposed	2015 unlikely	None announced	Changchun	Undecided	None stated

Note: Ranked by status and first flight
*Established but awaiting air operator's certificate (AOC). **Possible name
***HNA Group

Sources: airlines, local governments and local media

Heading Abroad

Chinese airlines' international traffic is rising 2.5 times as fast as domestic

Bradley Perrett Beijing

Toilet seats may seem like odd tourist attractions, but they are helping Chinese airlines. While Chinese domestic air traffic is no longer growing at anything like the rates common last decade, the carriers' international business is surging, with a strong bias toward Asian destinations such as Japan—the source of high-tech lavatories, a recent Chinese fad.

Hainan Airlines and Air China are also putting much more effort into long-haul business, with a focus on North America. And with Boeing 777-300ERs and 787s becoming available to them, they are increasingly confident of their international competitiveness.

Chinese mainland airlines' domestic passenger traffic, measured by passenger numbers, was up 11.7% for the first five months of 2015 from a year earlier, according to the Civil Aviation Administration of China (CAAC). Ten years ago, a 15% increase would have been common. But the airlines, like the rest of the country, are getting used to slower economic growth rates—what the government calls the new normal.

The carriers' international traffic, however, is not any kind of normal. It rocketed 27.5% over the same period. Tellingly, international passenger numbers, though not even 1/10th of the total, grew even faster, soaring by 39.4% and reflecting the emphasis on shorter routes.

Hangzhou, for example, is a large and prosperous city in the Yangtze

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Availability of 777-300ERs is helping Chinese carriers' confidence in international markets.

New Local

By converting a freight carrier, HNA can build up its Shanghai passenger business

Bradley Perrett Beijing

Looking out from a terminal at Shanghai Pudong International Airport you might see aircraft of 15 mainland Chinese passenger airlines. They are not equal.

Four are locals, with privileges. Two are special guests, with fewer privileges. And the others are merely guests and therefore have a strictly limited access to the air transportation market of China's largest city.

Soon there will be a fifth local. The Civil Aviation Administration of China (CAAC) has authorized HNA Group freight airline Yangtze River Express to carry passengers, creating a Shanghai passenger operations base that should strongly bolster the airline grouping centered on Hainan Airlines.

The move will alleviate a long-standing problem of HNA's airline business: its scarcity of connections between major cities. To some degree, the conversion of the freight airline poses a threat to the established locals at Shanghai, including China Eastern Airlines, although the problem will develop only as Yangtze River Express's passenger business does.

The freight carrier, which operates from Pudong, applied for a passenger carrier's license in 2013, say industry sources. The CAAC sat on the application until July 1, when it invited comment from interested parties, which really meant it was ready to approve. The authorization, revealed to Aviation Week by an industry source, has followed swiftly.

A rapid beginning of passenger operations, probably this year, is likely. Yangtze River Express already operates 23 aircraft—all freighters, mostly Boeing 737-300s and 747-400s—so it will not be starting from scratch. Meanwhile, its HNA siblings, well practiced at helping airlines begin operations, can supply management know-how, staff and aircraft. And Shanghai Pudong is one of the few major Chinese airports with spare capacity throughout the day, so slots are available.

River Delta. But its airport, Hangzhou Xiaoshan International, is badly placed for developing thin air routes, with Shanghai Hongqiao 138 km (86 mi.) away and Shanghai Pudong, by far the largest airport in eastern China, not much further.

Despite that mighty nearby competition, Xiaoshan has a flight to Tokyo Narita. And in March it started flights to Osaka and Mt. Fuji-Shizuoka in Japan. Chinese tourism, increasingly affordable to more even with slower rates of economic development, is driving this, say industry officials. Historical animosity between the nations notwithstanding, a great many Chinese are fascinated by Japan. Lately, this has extended to its elaborate toilet seats, boxes of which have become common sights on luggage belts at Chinese airports.

For its 2015 schedule, Air China set new flights from Beijing to Fukuoka and Hakodate in Japan, while also opening service to Kuala Lumpur, Malaysia, and between Tianjin and Jeju, a South Korean holiday island. In June, Shanghai-based budget carrier Spring Airlines connected Nagoya, Japan, with four Chinese cities mostly unfamiliar to Nagoyans but which will presumably produce a bounty of package tour groups: Hefei, Harbin, Shijiazhuang and Hohhot.

Air China is putting much more effort into its long-haul business than rivals China Eastern Airlines and China Southern Airlines. Its 2015 schedule includes new services, most less frequent than daily, between main base Beijing and Johannesburg; Montreal; Havana; Auckland, New Zealand; Melbourne, Australia; and Addis Ababa, Ethiopia. In addition, the route from Beijing to Los Angeles gained a third daily service.

Hainan Airlines this year increased its North American routes to seven from four and has applied to the CAAC to fly daily between New York and Tianjin, with an extension to Shanghai. Flights using 787s are slated to begin in June 2016. Hainan Airlines has also applied to fly five days a week between Tianjin and Vancouver, using Airbus

DAVID APPS/AIRLINERSGALLERY.COM

Under Chinese civil aviation regulations, Yangtze River Express has the great value of being a base company at Shanghai—that is, a local. The terminology is confusing, because a branch company, a special guest, also has operations infrastructure at its home airport—that is, a base—and a specific fleet of aircraft maintained there. In general, Chinese air services must radiate from the home airport of a base or branch company. The exceptions are not generous: airlines can set up small substitutes by getting permission to leave a few aircraft at other airports overnight, and a flight can stop at an intermediate destination.

Air China and China Southern Airlines have branch companies at Shanghai. HNA does not, so it has been largely limited to connecting the city with those places where one of its airlines has the necessary status. But Yangtze River Express, as a Shanghai base company, will be able to fly from the city to anywhere, subject to the CAAC granting the ser-

A330s, also to begin in June 2016. Beijing-based affiliate Capital Airlines, meanwhile, is moving into widebody operations. It plans to introduce Airbus A330s into its fleet this year and open services to Copenhagen in September.

Shanghai-based China Eastern has so far opened just one long-haul route this year, between Nanjing and Los Angeles. It has applied for a second, Shanghai-Chicago, but its main intention in doing so seems to be heading off Hainan Airlines.

That carrier has a Beijing-Chicago service and, according to industry sources, has wanted to add Shanghai-Chicago to its schedule. It has previously followed that pattern of flying to a North American destination first from Beijing, and then exploiting the established staffing and brand recognition to support a Shanghai service.

That possibility has now probably disappeared for a few years. Hainan Airlines would have great difficulty profiting from a Shanghai-Chicago service immediately after China Eastern began flying the route. More decisively, the CAAC appears to have an unwritten rule that once a Chinese airline is allowed on a route, no other will be added until several years later, after the first carrier's business is stably profitable.

Like China Eastern, China Southern's only new route so far this year is from a secondary Chinese city. It has connected San Francisco with Wuhan, with an extension to Guangzhou, the carrier's main base. An enduring problem for China Southern is how to make money with its five A380s. Its latest plan is to use them between Beijing and Amsterdam. Air China has warded off its rival's attempts at employing the giant aircraft on the much richer Beijing-Paris route.

—With research by Ryan Wang

Yangtze River Express operates a fleet of freighters, mostly 737-300s.

vice rights and permitting the carrier to grow in line with safe operations.

Second, in allocating service rights for an airport, the authorities treat a native base company more generously than a native branch company, and both more generously than base and branch companies flying in from elsewhere. A plum runway slot is most likely to go to a local, or a special guest.

Still, an airline such as Yangtze River Express, beginning passenger operations with probably only a handful of aircraft in 2015, is a long way from upsetting the business of China Eastern, which has a fleet of about 390, while its wholly owned subsidiary Shanghai Airlines, also a base company at Shanghai, has another 75. For example, at Beijing HNA has a branch company, part of Hainan Airlines, and a base company, Capital Airlines, but Air China remains a dominant presence.

Yangtze River Express also has to worry about the two other base companies—Juneyao Airlines and budget carrier Spring Airlines, both privately owned and therefore more nimble than China Eastern. And neither is small. Juneyao has 44 A320-family aircraft in service and 51 on order. Spring has 49 aircraft, also A320s, with 26 more to come.

Their new rival may to some extent sidestep them, however, by moving as quickly as possible into widebody operations. It will not be allowed to do so at first, but HNA is setting a precedent with Capital, an A320 operator that has plans to fly A330s to Copenhagen, which presumably will not be its last international destination. Again, the skills needed for that operation will be coming from elsewhere in the group, minimizing hiccups.

Hainan Airlines has slots at Shanghai Hongqiao International Airport as well as Pudong. The former is closer to the city center, but the potential for Yangtze River Express to grow at Pudong may tempt the group to consolidate at that larger airport. Yangtze River Express will presumably need to change its Chinese and English names, both of which sound like freight carriers' titles.

—With research by Ryan Wang

Fourth Gateway

Chengdu has most intercontinental services among second-tier cities

Bradley Perrett Beijing

Persistence pays. Nine years ago Chengdu welcomed the first scheduled air service to connect a secondary Chinese city with an intercontinental destination. This year, thanks to that Amsterdam service and others, the southwestern Chinese city has joined the ranks of China's main commercial air transportation centers, formally becoming mainland China's fourth long-haul gateway.

In 2006 the KLM service to Amsterdam put Chengdu a step ahead of rivals in the west and southwest of the country in what must have seemed like a pretty forlorn campaign for recognition by the national authorities as that fourth gateway. The Civil Aviation Administration of China (CAAC) was not interested in any of them taking the role. China had three major airlines, and each already had a intercontinentally connected main base at one of the three traditional first-tier cities: Shanghai, Beijing and Guangzhou. That was the well-established plan, and the CAAC stuck with it.

Yet Chengdu did not give up. As rival secondary cities lured long-haul services by foreign and domestic airlines, Chengdu lured more. Finally, in May the CAAC accorded Chengdu Shuangliu International a status equal to the airports of the primary cities. When the latest service, subject to CAAC approval, opens a connection with Paris in October, Chengdu will have nine intercontinental routes, as many as its next three challengers combined (see chart).

In general, Chinese secondary cities attract long-haul services with cash subsidies, say industry sources. At one point Wuhan, for example, paid Air France €30,000 ($32,550) for each of three weekly Boeing 777-200ER ser-

AIRLINES IN CHINA

Source: Airlines

*Destinations served by direct scheduled flights, including those authorized and planned.

vices to Paris. (Air France still found so much capacity unviable; it reduced frequency and aircraft size and asked for more money.) But the subsidies must be lower if the Chinese secondary city is developing unusually fast, as Chengdu has over the past decade.

Chengdu's commercial aviation success is only the brightest part of a picture of proliferating long-haul operations from Chinese secondary cities. Across the country, 27 such routes are in operation or firmly planned, compared with only four as recently as 2011.

Although KLM, Lufthansa and later Finnair and Air France have led the charge, China's three biggest carriers are now increasingly committed to linking secondary cities with Europe, North America and Australia. (Despite the common airline habit of lumping Australia with Asia, the country is, strictly, an intercontinental destination for China. Moreover, Melbourne and Sydney are farther from much of China than Western Europe is.)

U.S. carriers are almost absent from these markets. Only United Airlines participates, with a service between Chengdu and San Francisco. European destinations are also much better represented than those of North America; Frankfurt alone has four routes to Chinese secondary cities. Among the airlines, the most active player has been Chengdu-based Sichuan Airlines, which has three intercontinental services from its hometown and two from other cities.

Only a minority of the distant cities connected with the likes of Chengdu, Wuhan and Xian are among the world's top business centers. That reflects the predominance of outbound tourism in these Chinese markets. Few travelers from Sydney, for instance, can have business to do in Chongqing, nor wish to spend a holiday in that part of China. But millions of people in and around Chongqing would be eager for a holiday in Australia.

Air China is shaping up as the key player in Chengdu, where it has a secondary base for domestic services. Since the carrier's main base, Beijing Capital International, is constrained by airspace capacity, Air China probably looks with more than usual interest on Chengdu as an opportunity for long-haul growth. Frankfurt and Paris, the European cities that Air China serves or plans to serve from there, are among the most important long-haul destinations in its system. Its instigation of the services from Chengdu looks like network relief.

Still, two routes hardly turn an airport into a long-haul hub, as distinct from a gateway where flights from far afield arrive without much coordinated onward connection. The CAAC may be designating Chengdu as a hub, but Air China's domestic presence there means it is the only carrier that can match the name with reality, and it still has far to go before doing so. Among the five other carriers serving Chengdu with intercontinental flights, only United is a member of Air China's global airline alliance, Star.

The so-called Belt and Road policy of the administration of President Xi Jinping may have been decisive in the CAAC's decision to anoint Chengdu as a gateway. The policy emphasizes the need for China to strengthen its economic links with adjacent countries. Chengdu is not badly located for connections with central Asia, even though other, less developed cities are much farther west. China Southern Airlines has a base at Urumqi, perhaps the best located of all Chinese cities for connecting to European flights, but the city is far less developed than Chengdu.

—With research by Ryan Wang.

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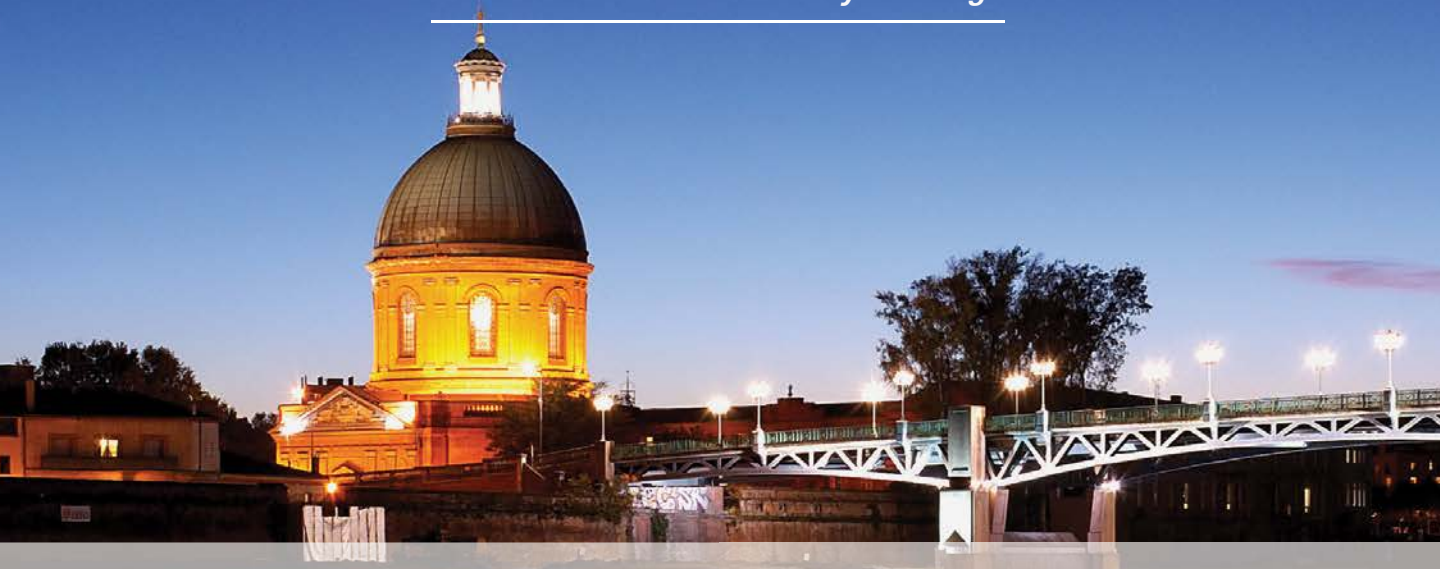

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Wires Crossed

Technology, like the military, marches on. But can the two go in lockstep? Does it matter?

The Northrop Grumman B-2 was a pure defense product.

Michael Bruno Boston and Washington

Pete Roney, Thales USA vice president for innovation and technology, is clear that the Pentagon is not the reason his Paris-based parent company is making investments here in the U.S. to find and spur innovation. But if it is interested in the results, great.

Northrop Grumman Chairman, CEO and President Wes Bush and Raytheon Chairman and CEO Tom Kennedy are just as clear, but even more ardent. They want the U.S. Defense Department to think twice before looking beyond heritage defense providers such as theirs.

Meanwhile, Rockwell Collins CEO and President Kelly Ortberg thinks his company already is doing what the Pentagon wants and is well-placed to profit from technology's changing landscape.

Above all, nobody seems to know what tech entrepreneurs in Silicon Valley, Cambridge, Massachusetts, or Austin, Texas, make of any of it, if anything.

Call it the shock and shrug strategy. The Pentagon's new high-profile outreach campaign to the U.S. technology sector and related new defense acquisition reforms in Washington are eliciting vehement reaction alternating with ambivalence from technology, aerospace and defense (A&D) industry proponents. In three months of talking with and listening to industry executives and representatives, think tank and financial analysts, and current and former defense officials about the April 23 Defense Department outreach, Aviation Week has found a wide range of responses ranging from acclamation to disbelief, with lots of uncertainty in between.

"I think the jury is out whether or not that is going to work," Roney says.

Of course, even that level of reaction represents a victory of sorts for the Pentagon. After all, it took Defense Secretary Ashton Carter's personal appeal to spotlight the outreach to tech startups and innovation giants alike, starting with a two-day trip to Northern California's Silicon Valley in April, where he delivered a speech at Stanford University. Then he visited Facebook's campus in nearby Menlo Park and met with executives at the $4 billon venture capital (VC) firm Andreessen Horowitz.

Carter's goals are to improve how the Pentagon partners with the tech sector nationwide and build "critical relationships" with entrepreneurs and executives, to help drive change inside the department. The outreach comes as Washington increasingly awakens to the fact that future defense technology will come more from the commercial sector rather than being government-driven, as it was during the Cold War (*AW&ST* Aug. 4, 2014). Underlying all of this is a fear that the U.S. military is at risk of losing its global technological lead.

In turn, Carter says technology startups and entrepreneurs should "renew the bonds of trust" with the military. While there is, and may always be, friction between the groups—including cultural differences best highlighted by opposing cybersecurity concerns—the fact is they all "live in the same world," he says. What they have in common is they all enjoy working on complex challenges that aim to make the world better.

To that end, the Pentagon is opening a so-called Defense Innovation Unit Experimental office in the Silicon Valley to serve as a physical interface with the tech sector. Meanwhile, the Secretary of Defense Corporate Fellows Program is being expanded to two years, one each in industry and government, as a means of increasing cultural exchange. Other personnel policy changes, such as sidestepping the time-on-station approach to defense promotion and benefits, also are being considered as ways of recruiting more techies to the government workforce.

Meanwhile, the Defense Department will make VC-style investments with In-Q-Tel, a not-for-profit, Washington-area organization created 16 years ago to "bridge the gap" between the U.S. intelligence community's technology needs and emerging commercial innovation. Pentagon acquisition czar Frank Kendall describes them as "relatively small investments," and sees nanotechnology and software as targeted areas.

BATTLE LINES EMERGE

All this may sound uncontroversial to most, but as Americans like to say, the devil is in the details. For starters, one policy reform stems from the Pentagon increasingly using its buying power as the single-largest A&D customer to induce more favorable commercial technology products and contract conditions, in the name of taxpayers. This touches on a long-running dispute between even the close-in heritage defense industry and the department over owning or controlling in-

tellectual property—especially as much of it in the U.S. is in one way or another nurtured by the government, including through university research and health care grants.

The latest skirmish in this arena is over a Pentagon acquisition regulation being crafted to require defense contractors to seek the department's endorsement for company-funded R&D projects for which they later expect to seek partial federal reimbursement as an allowable contracting cost (*AW&ST* April 27-May 10, p. 16). Immediately after Kendall unveiled it in April, contractors started complaining, but only at closed-door gatherings such as Washington trade association meetings. Now they and their lobbyists are increasingly airing grievances in public.

"The defense industry and the aerospace industry have great technologies, have done some marvelous things, and I would encourage the department to continue to look at the industry, and look at the industry through the same eyes that it looks at Silicon Valley, in terms of the requirements they lay on them, in terms of how they develop their products, and [in] how they provide their solution sets," Raytheon's Kennedy says. "Essentially, if you really want to compare apples and apples, I think you have to have a level playing field in terms of how you look at Silicon Valley and how you look at the defense industry."

Northrop's Bush is even blunter. "All R&D is not created equal when it comes to national security," he said at the Center for Strategic and International Studies (CSIS) think tank in May. "Commercial solutions—while an important ingredient in much of what gets done—in and of themselves are the not the answer for our national security need for technology superiority."

To be sure, commercial technology now sets the standards and the pace for many innovations, and there is a natural desire for Washington to avert the costs behind the old ways of doing things by tapping into that nongovernmental leading edge stream. But that is no panacea, Bush argues. For one thing, commercial tech is by definition broadly available, which is antithetical to providing for security.

Also, commercial companies have little business incentive to marry with the Pentagon as a long-term customer, as defense companies tend to do. In other words, software providers will stop supporting popular products as soon as they are no longer commercially viable. The youngest B-52 bomber, meanwhile, is more than half-a-century old and still being supported.

Commercial companies follow the big money, he continues. The automobile industry has no interest in stealth, nor is there much market demand for hypersonics, electronic jamming or advanced missiles. "No other nation could have created the B-2 bomber," Bush says of Northrop's program. "That was an effort that only defense R&D could have brought forth."

Bush's point about the commercial world's nondefense focus even gets a knowing nod from the head of the Defense Advanced Research Projects Agency (Darpa), once a partner with early-stage VC firm U.S. Venture Partners.

"In my 15 years in Silicon Valley, I spent time with some dazzling, amazing wonderful people, but zero of them [lay] awake at night trying to figure out how to defeat a Chinese IADS," Darpa Director Arati Prabhakar says about integrated air defense systems. "They don't know what IADS are—they just live in a different world—and to pretend that will just solve our national security problems is really shortsighted."

BOOTED UP

Some CEOs are confident they are already acting as Pentagon and tech sector go-betweens. Rockwell's Ortberg said as much in a recent interview with Aviation Week (*AW&ST* June 6-19, p. 66). So did Kennedy when he showed "the Cave" virtual reality chamber to Aviation Week at the Raytheon Integrated Air and Missile Defense Center in Andover, Massachusetts, in June.

"The department is right on, I think they should be looking at Silicon Valley, they should be looking everyplace," he says. "They should be pushing industry to be as competitive as it possibly can. They have to figure out how to stretch their dollar as far as possible. That's what we're doing here with the stuff in this room, trying to figure out how do we build this stuff at a lower cost? How do we make it more usable? How do we make it more maintainable?" he adds, pointing around the Cave Automatic Virtual Environment.

Some A&D CEOs are more accepting of the impetus to change. Airbus Group CEO Tom Enders says the industry must watch out for disruption from other businesses such as the virtual reality sector instead of from long-assumed national competitors such as China and Brazil (*AW&ST* July 2, p. 36). In turn, Toulouse-based Airbus is establishing a $150 million VC-like fund, dubbed Airbus Group Ventures, and like the Pentagon is opening its own Silicon Valley office. The fund is led by former Andreessen partner Tom Dombrowski, while the office is headed by Paul Eremenko, a former Google director of engineering and Darpa senior manager.

"The Defense Department is a good market for a startup company that's interested in cash. But the specialization needed to compete makes [it] less attractive."

"Silicon Valley serves as a unique hub for technology breakthroughs, and we see huge opportunities to learn from and partner with the many players based there," Enders said in May.

By comparison, other executives are making similar investments while seemingly moving beyond the Pentagon altogether. "We have sat down with some senior officials from the Pentagon to let them know that we are taking a slightly different approach. And that the approach is not necessarily defense-focus[ed], and not necessarily aerospace-focused—it's Thales-focused," Roney says.

In July, Thales announced a partnership called xPlor with the Media Lab at the Massachusetts Institute of Technology, an interdisciplinary incubator that has spawned the likes of the popular Guitar Hero video game. Multinational A&D and transportation provider Thales, which notched more than $17 billion in 2014 sales, calls xPlor its "most important U.S.-based innovation initiative." It sees the partnership as key in its drive to become a central player in the Internet of Things as that "megatrend" sweeps A&D, transportation and other sectors.

One new Thales product already credited to xPlor is

DragonFly, a head-worn surgical display that leverages its augmented reality technology used by military pilots in helmet-mounted displays. DragonFly puts critical surgical information directly in a surgeon's field of view—much like a pilot reading fuel levels while she tracks a bogey out the cockpit—allowing for constant "eyes-on" the patient during a navigated surgery. Earlier this year, it assisted in the first-ever navigated spine surgery using a head-worn augmented reality display, at St. David's NeuroTexas Institute in Austin.

PHOTOS: THALES

Thales credits an incubator for helping to transform its helmet-mounted display system (above) into a surgeon's tool (final product lower right).

"Our hope is that the innovations and connections we make will, as a byproduct of what we do, end up in the Pentagon, but not for the Pentagon," Roney says. "And I think in doing that, we're solving problems that are much bigger than just the United States defense establishment, which makes it a lot easier for the building to reach in and use some of our answers."

PROCESS IS PROBLEM

Nevertheless, perhaps the most important—and unknown—factor is whether tech entrepreneurs and start-up companies will respond to the Pentagon's or even legacy industry's outreach. In Washington, industry promoters such as the Lexington Institute are trying to piggyback on Carter's campaign to strike down old and proposed regulations that heritage providers do not like. "The problem is that federal regulations and defense acquisition policies and practices make the Pentagon an unattractive customer for many commercial firms, particularly those at the cutting edge of new technologies," says Vice President Daniel Goure.

Other observers agree, up to a point, but see greater clashes over profits and personalities at the Pentagon. "Are they a good customer for those potential and new entrants from places like Silicon Valley?" asks Coast Guard Commander Jason Tama, who has studied the issue in Silicon Valley as a Brookings Institution Federal Executive Fellow. "The answer is they are not a good customer. They are decidedly a bad customer for a number of reasons."

He points out the cultural divide. "One, being a culture of trying lots of things, failing fast and failing often, as a way to weed out different potential designs. That, versus investing in all your requirements up front, moving forward," he says.

Related to that are market differences. "The Defense Department, in many respects, is a smaller market than some of the global commercial markets, but it's still a good market for a startup company interested in cash," Tama says. "[But] one of the other problems that doesn't get talked about as much in the market is the specialization needed to compete, because the request-for-proposal process and strict, strict development of requirements make the Defense Department less attractive."

At the same time, the media-ready narrative of hacker-versus-soldier is not as big a deal, he says. True, some in Silicon Valley want nothing to do with the American sector that includes the National Security Agency. "But for everybody else in that ecosystem that I spoke to in my research—which is a huge volume of companies—outside of the business-to-consumer realm, there is no ideological opposition [to] doing business with the Pentagon," he says. "These people are interested in solving problems, making money for it and applying the best possible technology."

In the end, it may take a generation to determine what Carter's campaign achieves, but nearly everyone agrees it is a step in the right direction. "Secretary Carter's willingness to engage personally with Silicon Valley is an important step," says Andrew Hunter, the CSIS director of the Defense-Industrial Initiatives Group and until last November a senior defense acquisition executive in Kendall's office.

"But given that the target audience is literally thousands of small, innovative firms, it may take some time before the industry response is clear," Hunter adds.

Inside Baseball

They don't call it the military-industrial complex for nothing

Michael Bruno Washington

Last fall, at an Aviation Week conference dinner, a former high-ranking Pentagon acquisition official was seated near the founder and CEO of an up-and-coming subtier supplier to the aerospace and defense (A&D) industry. The entrepreneur told of some recent contract wins boosting defense revenue inside his company and talked of going further.

"Don't do it," the former Pentagon procurer interjected, bringing on laughs from the rest of the guests at the table. If it did, the company risked tripping a whole new level of oversight and costs from defense industry primes and their government customers, and the supplier executive might not find it worthwhile.

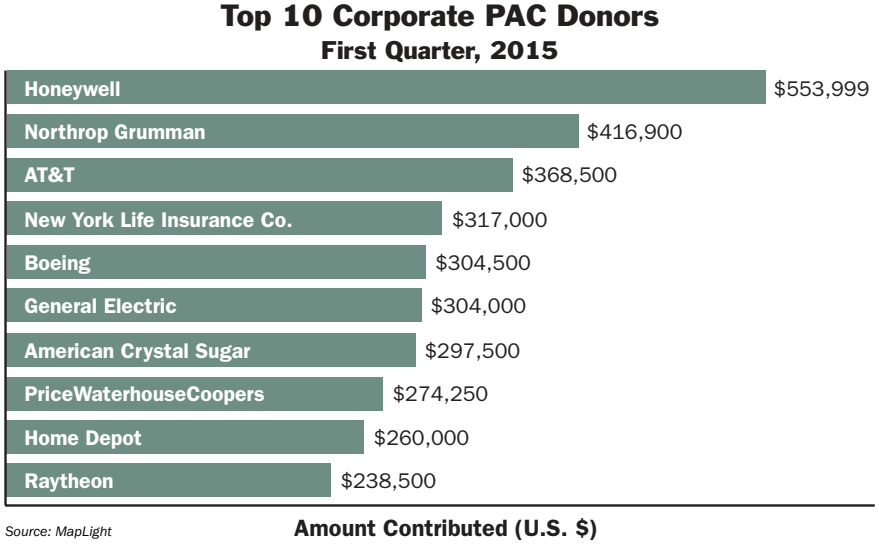
The executive left the conference still interested in building up his A&D business, both because of profits and patriotism. But the episode highlights some of the promises and perils of doing business with the Pentagon: It is its own universe, complete with laws and ways of doing things unseen anywhere else. Legacy defense primes and their Tier 1 suppliers know that, of course, and expect it to remain so even as Pentagon leaders look beyond heritage providers for technology and innovations (see page 58).

"If you are going to Silicon Valley, you're going to have to deal with Silicon Valley rules," says Raytheon Chairman and CEO Tom Kennedy. "They're commercial."

To be sure, many heritage defense providers would like the Pentagon and Congress to adopt more commercial approaches to doing business. But the fact is the government acquisition system is what it is in part because: 1) it spends taxpayer dollars, and 2) it provides for the security and well-being of the nation. Perennial political charges of waste, fraud and abuse aside, the system is set up in redundant layers to guard against those very things.

"Culturally we have evolved to a point where the system would rather pay $1 billion and 5% profit for a defense good, than $500 million and 20% profit," says Scott Chandler, a manager for Pratt & Whitney's military engine business who moonlights as an industry advocate with the Lexington Institute.

Moreover, all of that oversight comes only after a company lands a deal. On top of that, winning a contract means lobbying military requirements-setters and lawmakers alike. Not surprisingly, A&D often stands out when it comes to political action committee (PAC) spending. According to watchdog group MapLight's analysis of the highest first-quarter corporate PAC contributers to federal candidates' campaigns this year, half qualify as A&D stalwarts (see graph).



Those A&D companies, and others, know the system and the customer. Despite arguably hundreds of billions of dollars of wasteful defense spending since World War II, they have also ostensibly provided for the strongest military on Earth and helped get Americans to the Moon and back. While it remains to be seen how far the Pentagon looks beyond the defense industrial base for innovation, no matter what happens, that track record means a lot in a mission-oriented culture.

Consequently, some A&D cognoscenti think legacy primes probably will just adapt their business models to also serve as necessary "risk translators" to outside companies, on top of being platform, system and service providers. That term was used by Northrop Grumman Chairman, CEO and President Wes Bush in a May speech in Washington on the Pentagon's tech outreach.

"To me, R&D is a partnership issue," he says. "Marrying the tried-and-true to the truly exotic is what American innovators do best, and translating those efforts into solutions to support our security and to address tough challenges . . . that's the reason we have the defense industrial base, that's the reason we have our defense community partnerships. No other community can do it better, and this is what makes this community of partners a true national asset."

Bush calls for underpinning and even raising federal research and development, as well as making other industry-friendly reforms because, "like all national assets, we have to look out for it, we have to nurture it, we have to take care of it."

While the level of direct federal support likely will remain a contentious issue in the era of so-called sequestration spending caps and U.S. budget deficits, the defense industrial base is almost certain to receive some degree of support, if only to help make commercial tech work for Washington.

"All of this is not to say that the commercial world has no utility to the defense world. Of course it does," Bush says. "But I think that utility is as leverage, not as substitute."

Rocket Factory

Boosted by a OneWeb order, Virgin Galactic's LauncherOne is aimed at mass production

Guy Norris Los Angeles

Virgin Galactic aims to change the cost paradigm for putting smaller payloads into space by producing lightweight launch vehicles on an industrial scale similar to the commercial and military aircraft that were once made on the same site in Long Beach, California, over a span of more than 60 years.

It is a lofty goal for a company that has yet to send a vehicle into space, and whose target market is still emerging. Yet Virgin Galactic's ambitions for its LauncherOne vehicle are not based on a "build it and they will come" "Field of Dreams" philosophy but rather a hard-nosed, pragmatic and customer-driven business plan, says Vice President for Special Projects Will Pomerantz.

Virgin is targeting what it sees as a strange disconnect in the satellite world. Satellites have been following Moore's Law (which states that over the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two years) and have been getting smaller, more sophisticated and faster. But at the same time, launch vehicles have been getting larger and more expensive.

By marrying the airborne launch capabilities of the WhiteKnightTwo (WK2) carrier aircraft, developed for the suborbital SpaceShipTwo spaceplane, with new rocket engines and lightweight composite construction, Virgin believes it has the ingredients to resolve this disconnect. With first launch targeted for 2017, the market appears to support this belief, as evidenced by a OneWeb contract for 39 launches with options for a further 100, announced in June.

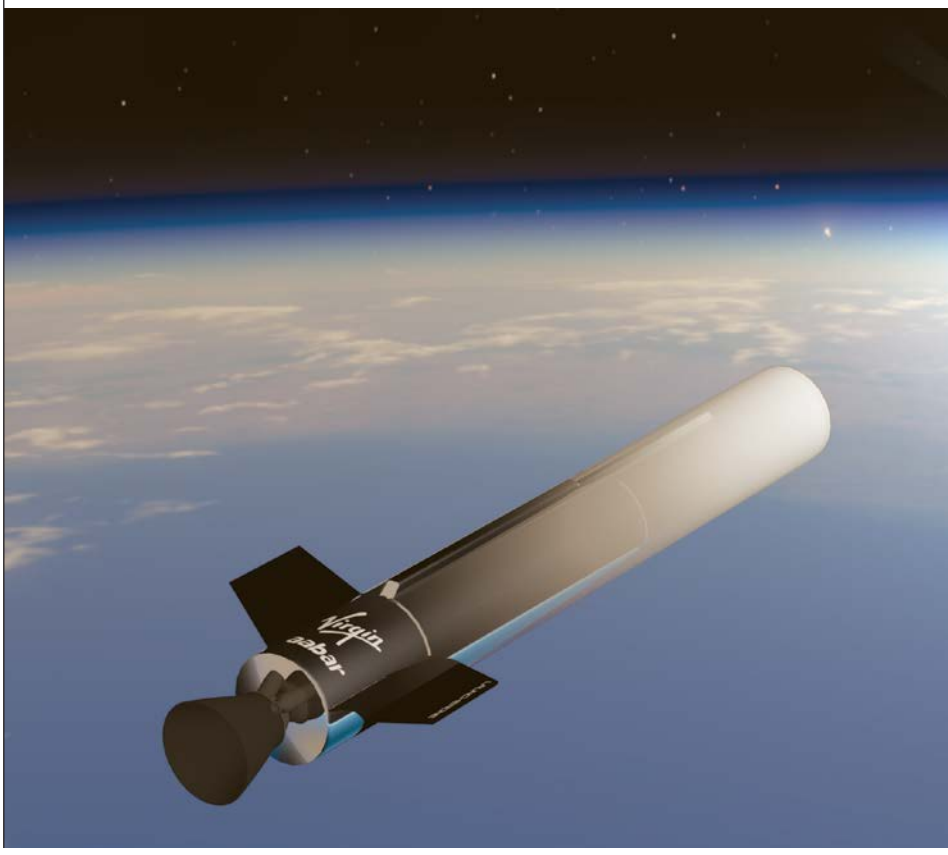
The deal coincided with a new $500 million funding round backed by several of the satellite company's equity partners, notably Virgin Group and Airbus Group. The latter will build the bulk of OneWeb's first-generation spacecraft at a U.S. site to be established later this year. Weighing less than 150 kg (330 lb.) at launch, the K_u-band satellites will be launched into polar orbit at an altitude of 500 km (310 mi.) before raising themselves to their operational orbit.

The value of the OneWeb contract to Virgin Galactic in terms of industrializing the low-cost launcher provider is "inestimable," says CEO George Whitesides. "On a scale of 1-10 this goes to 11 in terms of importance. It is the first firm contract we have announced for LauncherOne, and it sets us up for lowering our overall annual manufacturing costs because the contract is so big." The company is working with OneWeb to define the number of satellites deployed per mission, and Whitesides says the target for LauncherOne is "between one and three per launch."

Despite the large launch commitment to OneWeb, Whitesides says the production and launch tempo generated by the contract will also benefit other customers, including GeoOptics, Skybox Imaging, Spaceflight Services and Planetary Resources. "This sets manufacturing at a high rate and that will help all of us," he says.

He also adds that although OneWeb is the first firm customer to be announced, this does not necessarily mean its satellites will be the first to launch. "We'll have customers on the test launches but I cannot say definitively that OneWeb will be the first. But they will form a huge proportion of the first set of flights."

"The market is coming to fruition much quicker than I thought it would," says Pomerantz. "It's a very dynamic and fresh market. There looks to be a great diversity of customers with different time scales covering earth imaging, telecommunications, next-gen weather, asteroid mining and spaceflight servicing. So there are at least five different categories, and there many others we are talking to and others we have agreements with that we haven't disclosed yet," he adds. The caliber of the customers is also "one



of the things that has allowed Silicon Valley institutional investment to come in. It is one thing to convince a space professional to invest, but it is quite another to convince a dispassionate analyst at a venture capital firm."

Earlier this year, Virgin Galactic announced it would design and manufacture the LauncherOne launch vehicle in a leased 150,000-sq.-ft. building on a redeveloped part of Long Beach Airport formerly occupied by McDonnell Douglas. "The Long Beach site is open and operational. We have moved people in and we are building. We are starting to get machine tools and production cells set up, and the first parts are being made in there already. We are also testing various prototypes, so it is already a bustling hive of activity," says Pomerantz.

Provisionally designed to take 500-lb. payloads to low-inclination low Earth orbit and 265-lb. payloads to a high-altitude sun-synchronous orbit, the vehicle is targeted at less than $10 million per launch. However, Pomerantz indicates that some capabilities may change to reflect the demands of the market. "We keep it incredibly customer-driven. We have thorough and frequent checks with the customer community to make sure it meets their needs. Our requirements are continually evolving as new customers are continuously emerging. So we are trying to keep a finger in the wind, as it were, and are dealing with different orbits, volumes and mass. We are trying to find that delicate balance between moving forward and not backing into decisions before you have to.

"First launch remains on track for 2016," he adds. "We are focused on testing of the major components, including the liquid rocket engines and composite tanks. We've made a few iterations of each and we are getting better at it every day." First- and second-stage engines will be scaled-up versions of the same baseline liquid oxygen RP-1 (kerosene)-fueled, turbopump-fed rocket engine design. The booster stage, tested in prototype form as the Newton 2, will fire for around 2.5 min. following the release of LauncherOne from WK2. Provisionally rated at around 47,500 lb. thrust, the initial production version is dubbed the Newton 3.

The smaller upper-stage Newton variant is rated at around 3,500 lb. and designed to burn for up to 5 min. The prototype engine was called Newton 1, while the production version will be the Newton 4, says Pomerantz. Hot-fire testing is being conducted at two new purpose-built stands in Mojave, California, across the airfield from where the company's second SS2 is under assembly.

Vehicle development work is centered on ensuring the structure—which incorporates composite propellant tanks—is producible at a high rate. "We stress to our team that manufacturability is an innate part of this rocket. One of the key selling points is affordability and if you neglect the manufacturing part, then in turn the affordable engine turns into an expensive engine, relatively speaking. We want to crank these out and that will happen at Long Beach. Manufacturing is the key, and we have been building and testing tanks to make sure we have the basic process down pat," says Pomerantz.

LauncherOne is off to a solid start following a OneWeb contract for 39 launches plus options for a further 100 as part of plans to deploy a constellation of more than 600 low-orbiting Internet satellites.

VIRGIN GALACTIC

Power Promise

Reaction Engines focuses on Sabre demonstrator plan as interest grows in air-breather

Guy Norris **Los Angeles and Glasgow, Scotland**

It is a well-established truism in aerospace that leaps in propulsion technology almost always precede major advances in spacecraft or aircraft design.

As the clamor for affordable access to space continues to grow, there is mounting interest in the Synergetic Air-Breathing Rocket Engine (Sabre) concept under development by U.K.-based Reaction Engines. This hybrid powerplant is designed to bridge the infamous power gap between air breathers and rockets, potentially enabling a vehicle to accelerate from a standing start on the runway all the way to low Earth orbit.

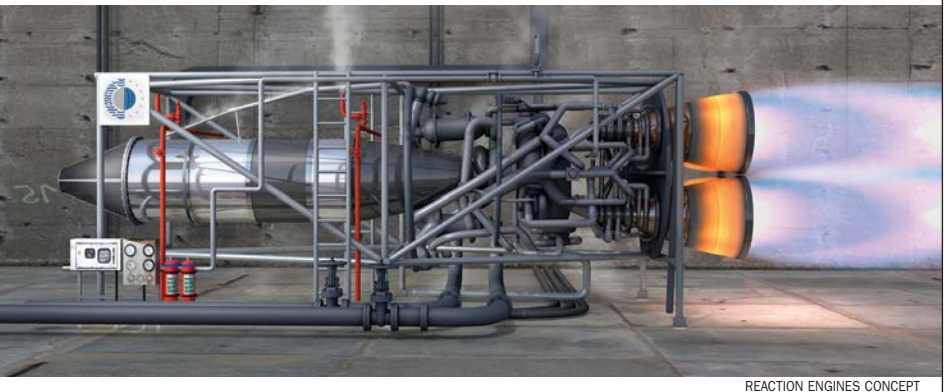
Such an engine could power high-speed aircraft, suborbital craft or even multi- and single-stage-to-orbit vehicles. Even more encouraging to Sabre proponents is that, while earlier attempts to harvest oxygen from the atmosphere succumbed to thermodynamic reality, the Reaction design continues to pass muster with experts in Europe and the U.S. The company's most recent—and possibly most valuable—vote of confidence comes from the U.S. Air Force Research Laboratory (AFRL), which analyzed Sabre under a cooperative research and development agreement.

AFRL's validation followed a detailed study of the entire concept, particularly the precooler heat exchanger technology, which allows for the practical extraction of oxygen from the air without clogging up the mechanism with frost and ice. Reaction unveiled initial details of the methanol-based frost-control system at the American Institute of Aeronautics and Astronautics Hypersonics and Spaceplanes conference in Glasgow in early July.

AFRL program manager Barry Hellman says analysis "confirmed the feasibility and potential performance

of the Sabre engine cycle. While development of the Sabre represents a substantial engineering challenge, the engine cycle is a very innovative approach and warrants further investigation." As a result, Reaction Engines and AFRL plan to continue collaborating on Sabre, with potential follow-on work focusing on evaluation of various air-breathing-powered vehicle concepts and testing of specific engine components.

The AFRL study will also evaluate other potential uses for the Sabre's heat exchanger technologies, including looking at broader defense applications. "The question to answer next is what benefit the Sabre could bring to high-speed aerospace vehicles compared to other propulsion systems," says Hellman. "AFRL is analyzing vehicle designs based on the Sabre engine concept. We are also considering testing their heat-exchanger technology at Mach 5 flight conditions in a high-temperature wind tunnel."



REACTION ENGINES CONCEPT

While AFRL acknowledges that Sabre's original target—a single-stage-to-orbit space access vehicle dubbed Skylon—remains technically "very risky as a first application," Hellman says: "Sabre may provide some unique advantages in more manageable two-stage-to-orbit configurations."

Reaction Engines agrees. "From our perspective there is no cheap, quick way around the problem of space access. We've done studies and we agree that [a] sensible second-stage approach might be best to demonstrate the technology by taking it one step at a time," says Sam Hutchison, director of corporate development at Reaction Engines.

Hellman also believes the heat exchanger technology "warrants further investigation for applications across the aerospace domain. Our primary interest is testing the heat exchanger technology. It could have many potential aerospace applications beyond just the precooler concept used in the Sabre engine."

The precooler chills the incoming air from more than 1,000C (1832F) to -150C in less than 1/100th of a second, before passing it through a turbo-compressor and into the rocket combustion chamber, where it is burned with subcooled liquid hydrogen fuel. For higher altitude operation and the jump to orbit, the engine switches to an onboard liquid oxygen supply and runs as a conventional closed-cycle rocket engine (*AW&ST* Nov. 26, 2012, p. 47).

Unlike other liquid-air-cycle engines, which use cryogenic liquid hydrogen to liquefy incoming air, the Sabre uses a closed-cycle helium loop consisting of miles of tightly packed, thin-walled tubing which cools the air down only to the point where it forms a vapor. The vaporized air is then injected by the turbo-compressor at high pressure into the combustion chamber.

"AFRL signing off on the Sabre engine is potentially game-changing," says Hutchison. This validation of the cycle added to that from the European Space Agency in 2014, under a U.K.-requested independent review, "gives people confidence that this technology could be potentially transformational.

"Enough people now say the Sabre cycle works and it looks compelling. Now the question is what will we do with it?" says Hutchison. "As an engine class, it straddles both air and space, so we have to optimize a system to take advantage of that for a given application. As we structure the development plan going forward, we can figure out what the first use is going to be. So over the next six months we will be closing in on that application."

A big part of the strategy is anchored on the successful test of a full-scale Block 1 ground demonstrator engine at the company's facility at the Culham Science Center in Oxfordshire, England. "Right now we are in the process of scoping that demonstration engine in terms of what it needs to achieve," says Hutchison. "The key thing is to tick the boxes in every area it needs to tick. It is all about making sure the demonstrator meets the performance requirements that are set for it. We want to make sure it really works and offers the sort of performance that we say it can do. We're still in that phase. The studies are in their infancy for the engine demonstrator but we have got to make sure we're not biting off too much more than we can chew."

A target date of 2018-19 for the first full engine to test is within reach for the demonstrator, he says.

Ground testing of the high-Mach-number Sabre cycle is feasible, says Hutchison, "because the engine uses the atmosphere as the source of its energy and the reaction mass. And because of the clever heat-exchanger technology, we can modulate the air so the turbomachinery in the engine doesn't know it is on the ground." Higher-velocity air is simulated by heating the air flow and, as the temperature of the air entering the engine is ambient, "we can simulate that on the ground all the way from Mach 0 to Mach 5," he says. In addition, inlet tests will be conducted in wind tunnels to evaluate flow conditions.

Reaction Engines plans full-scale Sabre ground demonstrator engine test in 2018 or 2019.

Funding also remains secure, says Hutchison. "We are in the process of finalizing the terms of the U.K. government's £60 million ($93.6 million) grant and, in addition, we did a very successful financing round last year. We have no short-term financial shortfalls and as we move forward on bringing in partners, we will seek to raise additional financing where necessary."

After AFRL's validation Reaction seems increasingly confident as it transitions from "a research-focused company to a production-focused company," he adds. "Everyone said it couldn't be done, and in 2012 we did it. We ended up with an engine that on paper has six times better fuel consumption than a rocket engine."

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Mega Launcher

Stratolauncher widens payload options to broaden capability

Guy Norris Los Angeles
and Amy Butler Washington

Air launching a vehicle to orbit is not new. Orbital ATK has been releasing the Pegasus rocket from a Lockheed L-1011 for 21 years and Virgin Galactic is poised to begin test flights of the LauncherOne from beneath the WhiteKnightTwo (WK2) carrier aircraft sometime next year.

But the enormous carrier vehicle under development by Vulcan Aerospace's Stratolaunch Systems takes the concept to an entirely new level. The six-engine, 385-ft.-span aircraft is designed to loft medium rockets to a launch altitude from where they can place payloads up to 13,500 lb. into orbit compared to 1,000 lb. or less for all other air-launch systems.

The key advantage of air launching is that by using wing-borne lift to reach release altitude, first-stage mass can be dramatically reduced, significantly lowering overall launch costs. The space shuttle, for example, expended around one-quarter of its total propellant mass to reach an altitude of 35,000 ft.—a typical height at which air launch occurs. Launching from altitude at aircraft cruise speeds can also add 1,100-1,800 fps in velocity change (delta V) capability. The lower density of the higher altitude launch also means rockets can be designed with higher expansion ratio nozzles for a given engine pressure ratio.

STRATOLAUNCH SYSTEMS

One of few images to emerge from inside the Stratolaunch assembly site indicates the massive scale of the yet-to-be-completed launcher aircraft.

Operationally, air launches also can reduce costs by their greater flexibility and responsiveness. Because the launcher is not tied to a specific location, it can maintain a schedule by flying over or around weather, and can achieve any launch azimuth without having to fly out-of-plane maneuvers. Most air launch systems do not require much ground infrastructure.

Since Stratolaunch was revealed in late 2011 as a collaboration between inventor and philanthropist Paul Allen and Scaled Composites founder Burt Rutan, development of the carrier vehicle has remained largely on track, with rollout now expected in early 2016. The target market, on the other hand, or at least the definition of that market, appears to be broadening as the carrier vehicle takes shape inside the company's cavernous assembly site in Mojave, California. The change is reflected in the fact that Orbital ATK, which was previously developing the Thunderbolt rocket for the launch aircraft, is no longer working with Stratolaunch on this project.

"[We are looking at] potentially having multiple launch vehicles—like a family of them," says Vulcan Aerospace President Chuck Beames. "So what is the smart way to do that? The original idea was to have one pylon, and then possibly different size pylons for different size rockets. Now we are [considering] a universal pod and then we can carry anything."

Beames first hinted at the change in direction at this year's Space Symposium in Colorado. He said Stratolaunch was focusing more on a lower-cost, potentially evolvable propulsion system, as well as on a greater means of accessing the emerging small satellite market. As a result, Beames also indicated the company was deferring work on a 75%-scaled version of Sierra Nevada's Dream Chaser crewed vehicle that was being designed for launch on the now shelved Orbital ATK booster.

The universal pod attachment will be carried underneath the center wing so "we can open the doors below to release and so can carry a lot of different-size rockets," says Beames, who adds that the center wing is designed for a lifting capacity of just over 500,000 lb. "It is a very beefy center wing. It has six hardpoints now so it can handle a lot more aerodynamic flex than a simpler wing."

Although conceptually similar to the Scaled Composites-designed WK2, Beames says the Stratolaunch carrier aircraft is not "a simple scale-up" of the Virgin Galactic launcher. "It is obviously huge and size makes a difference in a lot of things, not just scale. When you have that much lift, it gives you much more capacity to hang on that center wing. So you need to design it differently [to] service a broader range of capabilities and have more stability for a wider range of payloads."

Several manufacturing innovations, some of which were also employed on WK2, have been used to produce the largely composite launcher aircraft, nicknamed "Roc" by Stratolaunch workers. "There are eight wing spars and they are about 230 ft. long." Rather than going to the expense of building a huge autoclave to cure the composite spars, Scaled Composites built a movable oven. It laid out all the composites and then moved the oven along to "cook the spar," he adds.

The aircraft also integrates several parts, structures and systems from two Boeing 747-400s, including six Pratt & Whitney PW4000 engines. "We also used a lot of avionics, the landing gear and windows," says Beames, who explains: "Certification is a big deal so these 747 windows are certified for bird strikes; by reusing them, that saves a lot of money in testing and so on."

Assembly remains on target, says Beames, with more than 80% of the structure fabricated and around 40% assembled. "We should have the aircraft completely assembled by the end of the year or early next year." Following low- and high-speed taxi tests, first flight is slated for late 2016. "I will be holding my breath for that first liftoff—it will be an awesome sight."

Reusable Race

As SpaceX edges closer to a first-stage recovery, others explore alternative reusability options

Guy Norris Los Angeles and Glasgow, Scotland and Graham Warwick Washington

While few in the space business dispute that reusability is the key to dramatic reductions in the cost of space transport, there is less agreement on the best way to achieve this goal.

Since the retirement of the winged space shuttle, the first technically reusable—but massively expensive—launch vehicle, the industry has redoubled efforts to achieve some form of reuse. With multistage and air-launched concepts still in initial development, SpaceX has done more than anyone else to prove a conventional rocket can be reused as part of a lower-cost launch system.

While the June 28 failure of its Falcon 9 mission to resupply the International Space Station has temporarily put the brakes on SpaceX's attempts to land a used first stage, the company remains focused on its goal of producing a fully and rapidly reusable rocket system. SpaceX founder and chief technology officer Elon Musk says reusability is a fundamental enabler of lower launch costs. He says a large commercial airliner costs about the same as a Falcon 9, but "airlines don't junk a plane after a one-way trip from L.A. to New York."

With each try since the first attempt to recover to a drone ship in the Atlantic Ocean in January, SpaceX has edged closer to landing a first stage after launch. To achieve this the Falcon 9 is configured with nitrogen gas thrusters and foldable grid fins, or X-wings, to reorient and steer the first stage as it reenters, as well as with deployable carbon fiber landing legs. The control and operation of these devices is totally automated once the rocket is launched. The stage is also designed to carry additional fuel margin to light three engines for a "boostback burn" to slow the rocket, as well as additional burns for reentry and landing.

Baseline procedures and systems were developed and tested by SpaceX on dedicated experimental vehicles and regular flights. The fins were added to augment the gaseous nitrogen thrusters after the first stage rotated beyond control limits on the first test flight in September 2013. Prototype versions of the steerable fins were tested for the first time in May 2014 on a flight of the Falcon 9 Reusable (F9R) experimental vehicle during a test that reached an altitude of 1,000 meters (3,300 ft.). Additional hydraulic fluid to power the fins was added after the first landing attempt on the drone ship failed in January 2015 when the system became depleted.

SpaceX came closest to success with its second full attempt in April. Although the descent was successful, "about 10 sec. before landing, a valve controlling the rocket's engine power temporarily stopped responding to commands as quickly as it should have. As a result, it throttled down a few seconds later than commanded, and—with the rocket weighing about 67,000 lb. and traveling nearly 200 mph at this point—a few seconds can be a very long time. With the throttle essentially stuck on 'high' and the engine firing longer than it was supposed to, the vehicle temporarily lost control and was unable to recover in time for landing, eventually tipping over," says SpaceX.

United Launch Alliance (ULA) is taking a different approach to reusability by focusing on recovering the launcher's most expensive element, its rocket engines, rather than the entire first stage. ULA CEO Tory Bruno, who revealed the reusability element as part of the new Vulcan launch vehicle initiative in April, says it will be a "game changer" for the exploration and exploitation of cislunar space when introduced in 2019.

ULA's plan calls for the paired first-stage BE-4 engines, following cutoff, to be physically detached from the base of the core by a shaped explosive charge. The device will sever the propulsion systems at a specially designed separation interface built into the thrust structure between the engine mounts and the base of the stage. The device will also cut through the large feed pipes supplying oxygen and fuel to the thrust chamber, be it methane or kerosene.

Following separation the joined engines will be cocooned to protect them during reentry by a 12-meter-dia. device called a hypersonic inflatable aerodynamic decelerator. This consists of a set of concentric doughnut-shaped rings made of braided Kevlar. Each tube in the ring, or torus, will be lined internally with silicon and held to its neighboring torus by Kevlar straps.

Falcon 9's landing legs lower as the first stage approaches the drone ship during an April recovery attempt.

SPACEX

Once slowed to low subsonic speed, the engine unit will descend towards the ocean under a large parafoil. At lower altitude the parafoil and its cargo will be caught midair by helicopter. ULA graphics of the midair capture phase indicate the use of a large tandem-rotor Boeing CH-46, which has a cargo hook capacity of 10,000 lb. Other suitable models could include the CH-47, which has a single-point load capability of 17,000 lb. on its forward hook or a center cargo hook capacity of 26,000 lb. The Sikorsky CH-53E, which has a single-hook capacity of 20,000 lb., could provide another option.

Airbus Defense and Space also is looking at recovering only the most expensive parts of the rocket, the engines and avionics, which make up 70-80% of the value, it says. The European company's Adeline concept is being proposed for use with the new Ariane 6 launch vehicle, beginning in 2025. Airbus estimates recovery and reuse will cut the cost of an Ariane 6 launch by up to 30%.

Adeline (for Advanced Expendable Launcher with Innovative Engine Economy) is a winged reentry module that houses the core-stage engines and avionics. After burnout, the module will separate from the first-stage fuel tank, exposing a rounded, aerodynamic heat shield that will protect the motor and systems during a ballistic reentry at Mach 5+. After reentering the atmosphere and pulling up into level flight, two wing-mounted turboprop engines will deploy small propellers and the module will cruise back to a remotely piloted runway landing. The complete module will then be refurbished and reused.

Airbus says Adeline protects the rocket motors from the high dy-

SPACEX

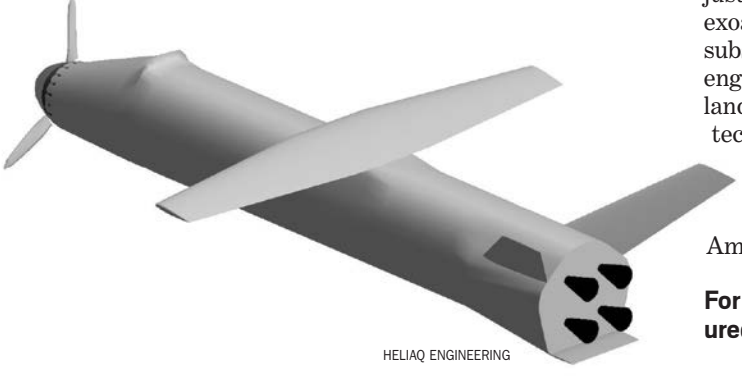
Flyback Options

Reusable small satellite launch system could be 'once in a generation' chance for scramjets

Guy Norris Glasgow, Scotland

Australian researchers are planning subscale demonstrations of the first stage of a multistage space launch system for small satellites that would utilize both flyback boosters and a reusable, scramjet-powered second stage.

This aims to take advantage of dramatic growth in the small satellite market, and could provide a "once in a generation opportunity for our hypersonic community to join the space community," says Michael Smart, chair of hypersonics at the University of Queensland (UQ), Australia. The project would combine a hypersonic accelerator with a flyback first-stage booster conceived as part of a modular series of rockets called the Austral Launch Vehicle (ALV). The system is designed to deliver up to 500 kg (1,100 lb.) into a sun-synchronous, 570-km (354-mi.) orbit.



HELIAQ ENGINEERING

The ALV booster, which originated from an academic research project, is similar to the U.S. Air Force X-37B orbital test vehicle, with a V-tail and ventral body flap. However, unlike the delta-wing Boeing-built spacecraft, the ALV is configured with a pivoting, oblique wing and a nose-mounted deployable propeller for a powered return to a runway landing.

"It is difficult to install a jet engine, to find one that is the right size and one that could operate efficiently at such slow speeds. So we came up with a [piston-powered] propeller as the best option," says Adriaan Schutte, creator of the ALV and head of Heliaq Advanced Engineering, the Brisbane, Australia-based company behind the project. The pivoting wing, already proven feasible during NASA's AD-1 experimental program from 1979-82, will be stowed flush with the crown of the vehicle for launch.

"We do a normal ascent, then we separate. Up to now no one has separated the first stage from a parallel upper stage controllably. Normally your first stage is expendable and you just throw it off," says Schutte. "After we separate and fly exoatmospherically in reentry configuration, we slow down subsonically, open the wing and start a nose-mounted piston engine. The propeller folds out by centrifugal force and we land like a big UAV essentially." He says several additional technologies would have to be developed, including systems to ensure the piston engine will start after its exoatmospheric excursion.

Smart, who spoke to Aviation Week while at the American Institute of Aeronautics and Astronautics Space-

For recovery the reusable ALV first stage will be configured with an oblique wing and deployable propeller.

The SpaceX drone ship fleet is being upgraded to improve the chances of a successful recovery.

namic heat flux experienced by the Falcon 9's engines during reentry, and because the module's turboprops are powered by jet fuel stored in the wings, there is no reignition of the rocket motors for landing. This avoids the payload penalty SpaceX incurs for the extra rocket propellant required to recover the Falcon 9's first stage, Airbus argues.

So far, about $17 million in company money has been spent over five years on the Adeline concept, including flight tests of subscale demonstrators, and Airbus is seeking external funding to continue development. Ongoing work includes finalizing an aerodynamic shape for the winged module that works in both the supersonic reentry and the subsonic cruise, approach and landing domains.

Other efforts include Darpa's XS-1 experimental spaceplane program, to demonstrate a fully reflyable first-stage booster. The goal is to develop aircraft-like reusability, demonstrate the capability to fly 10 times in 10 days, and prove out the technology for an operational vehicle able to lift 3,000-5,000 lb. to low Earth orbit for less than $5 million per launch.

Three teams are wrapping up the 13-month Phase 1 preliminary-design contracts awarded in July 2014: Boeing with Blue Origin, Northrop Grumman with Scaled Composites, and Masten Space Systems with XCOR Aerospace. Masten is designing the Xephyr, a vertical-launch, vertical-landing reusable booster. Northrop is working on a vertical-launch, horizontal-landing spaceplane. Boeing's design resembles its X-37B minishuttle, so it is likely launched vertically to land horizontally.

planes and Hypersonics Conference in Glasgow, says a subscale demonstrator (ALV-0) with a 3-meter (9.8-ft.) wingspan will be flown by year-end. "It will take off like a normal aircraft, stow the wings and then redeploy them. It will all be about the slow speed handling and also to show that it could work."

A follow-on rocket-powered demonstrator is also planned, but requires funding, he says. "The next demonstrator [ALV-1] would be the same scale and powered with a simple rocket booster. It would launch vertically and go through the whole sequence, fly supersonically, do a controlled reentry with the body flap, deploy the wings, turn on the motor, turn around and come back to base. We are trying to concentrate on the new things, not the classic rocketry things that have been done before," says Smart.

The ALV-0 testing will take place in Australia but the venue for ALV-1 testing could "possibly be in Europe," he adds. "We are going to apply for support from the U.K. Space Agency, but if we got funding from the Australian government we may do it in Australia."

Although the basic ALV architecture is designed around multirocket-powered stages, Smart says UQ and Heliaq are studying integration of a scramjet-powered vehicle as a second stage. The 22-meter-long Spartan (scramjet-powered accelerator for reusable technology advancement) vehicle is configured with a sharp delta wing and four scramjet engines clustered around the lower fuselage. Designed to bridge the gap between the first-stage ALV booster and an expendable liquid-rocket-powered third stage, the Spartan would accelerate the payload stage from Mach 5 to 10.

The third stage will be "nestled" in Spartan's upper fuselage, which will "allow a clean release and a practical way of staging," says Smart. "We'll use liquid hydrogen as fuel, and we want enough fuel to get to Mach 10. It is better to have a low-drag vehicle with lots of volume, more than a waverider. It's all about integration of the scramjet engines into the vehicle, so we have adjusted the REST [rectangular to elliptical shape transition] design to have a different capture area. We called it a conical REST so we don't have to worry about shock inlet conditions."

The Spartan "requires a lot more technology development" before it can become part of the ALV architecture, he says. "It is about having both reusable first and second stages. Once you have an air-breathing second stage, it changes the whole idea of a rocket system. As soon as you introduce a high lift-to-drag air-breathing vehicle you have far more operational flexibility, and if the weather is bad you can turn around and come back."

The Spartan second-stage vehicle will be powered by four scramjets clustered beneath the fuselage.

UNIVERSITY OF QUEENSLAND

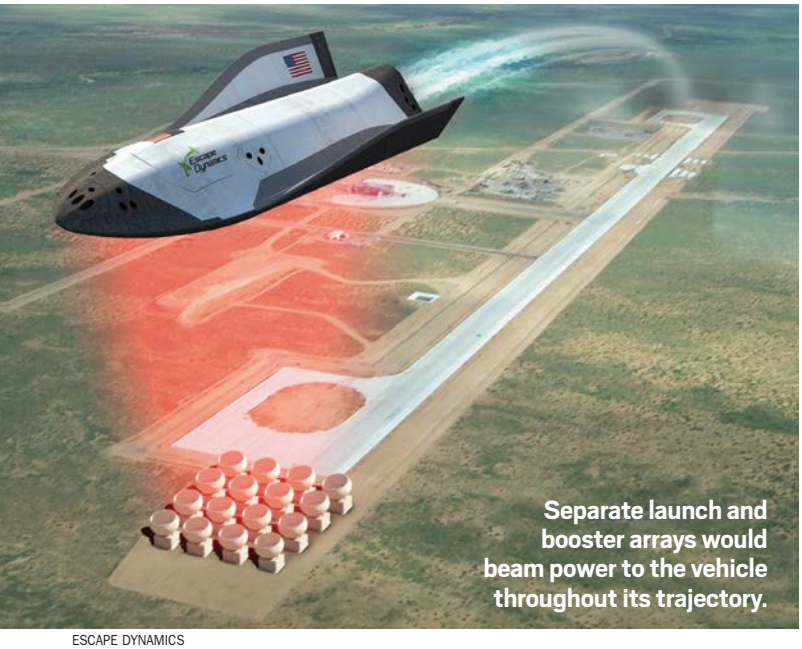
Beam Me Up

External microwave propulsion key to single-stage-to-orbit launcher

Graham Warwick Washington

Tests of a combustion-free thruster have boosted a start-up's hopes of using microwave beaming from the ground to power a small single-stage-to-orbit (SSTO) reusable launch vehicle—something that has yet to prove possible with chemical rocket propulsion.

In laboratory tests, says Escape Dynamics, the thermal thruster demonstrated a specific impulse (Isp)—a measure of rocket engine efficiency—greater than 500 sec. using helium as the propellant. Had hydrogen been used instead of helium, Isp would have been above the 600-sec. threshold required for SSTO operations, the Bloomfield, Colorado-based company says.



Separate launch and booster arrays would beam power to the vehicle throughout its trajectory.

ESCAPE DYNAMICS

Converting electricity to microwaves and beaming them through the air to heat hydrogen may not seem the most efficient way to power a launch vehicle. But eliminating the need to carry liquid oxygen reduces the fraction of vehicle mass that is propellant below 72% and increases the fraction that is payload to 8-12%, from 1.5-3% for a conventional rocket, the company calculates.

In Escape Dynamics' concept, millimeter-wave energy is beamed from a ground array of high-power transmitters through the atmosphere to a silicon carbide heat exchanger on the underside of the launch vehicle. Cryogenic hydrogen is pumped at high pressure through the exchanger, rapidly heated to above 2,000C (3,630F), and expanded through an aerospike nozzle to provide thrust without combustion.

The thermal thrusters can achieve a vacuum specific impulse of 750-850 sec. compared with around 450 sec. for a conventional rocket, the company estimates based on its test results. A next-generation system in which external microwave power directly heats plasma flowing through a resonant cavity promises an Lsp above 1,500 sec. and a propellant mass fraction below 50%, Escape Dynamics says.

Before each launch, electricity from the power grid would be stored in batteries. An estimated 65 megawatt-hr. of power is required to launch a vehicle carrying a 100-200-kg (220-440-lb.) payload into low Earth orbit, says Dmitriy Tseliakhovich, CEO and chief technology officer. The battery banks would take about 6 hr. to charge up and would discharge rapidly, in 400 sec., as the vehicle ascends into orbit.

There will be two high-power microwave ground arrays, each with about 800 steerable, 500-kW transmitters. A launch array optimized for 50-100-km (30-60-mi.) range will power the vehicle through the initial part of its trajectory. A booster array located 200-250 km downrange and optimized for 350-450-km range will accelerate the vehicle to orbital velocity.

Once in orbit, the spaceplane will not need beamed power. After the satellite is deployed from its payload bay, monopropellant thrusters will be sufficient to deorbit the vehicle, says Tseliakhovich. The silicon carbide heat exchanger will serve as thermal protection during reentry, and the lightweight lifting-body spaceplane will glide to a runway landing.

Challenges to be overcome include generating the high-power microwaves and delivering the energy to a moving vehicle, as well as converting it as efficiently as possible to thrust. Escape Dynamics has developed its own gyrotron to convert electricity to microwaves. "That has taken a lot of the time over the last 3-4 years," says co-founder Richard Shaden. "But the theoretical part is all done. From here on, it is manufacturing and assembly."

The lab tests used a 100-kW high-power microwave system operating in a continuous-wave mode at 92.3 GHz. The power was beamed 5 ft. across the lab to a heat exchanger and thruster. Within the next 6-8 months, Escape Dynamics plans to move testing outside—likely to White Sands Missile Range in New Mexico—and begin outdoor testing by beaming power to a small unmanned aircraft.

"By then we will be constructing the 500-kW unit," says Shaden. "Then we want to move from one to two antennas, to play with the phasing of the beams." The company then plans to build up the power to multi-megawatt levels and begin flying external-propulsion vehicles. "The technology will be ready in several years. By the turn of the decade, or early 2020s we should be in orbit."

Combining the beams from the hundreds of transmitters in an array is a "solvable challenge," Tseliakhovich says. "It has been demonstrated on a tens of megawatts scale by the tokamak [fusion research] industry. It is not an easy problem to solve, but we know it is possible." Precisely controlling the moving vehicle and beams is another challenge, "but we are developing the tracking algorithms," he says.

Safety is a concern when beaming such high levels of microwave power, and Escape Dynamics has developed a sidelobe-suppressing antenna design. The company has shown a safety interlock can turn off the beam "with extreme speed," Tseliakhovich says. "The question is how quickly can we detect an aircraft or a bird." If power beaming is interrupted, there is enough thrust inertia for the vehicle "to contine to fly if we restart the beam in a few seconds," he says. If not, the vehicle can glide back to base.

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Future Events

Oct. 13-15—MRO Europe. London.
Nov. 3-5—MRO Asia-Pacific. Singapore.
Nov. 3-5—AerospaceDefenseChain. Scottsdale, Arizona.
Jan. 21-22, 2016—MRO Latin America. Lima, Peru.
Feb. 3-4, 2016—MRO Middle East. Dubai.
March 3, 2016—Laureates. Washington.
April 4-5, 2016—Brazing Symposium. Dallas, Texas.
April 5-7, 2016—MRO Americas. Dallas, Texas.

Aerospace Calendar

To submit Aerospace Calendar Listings
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Aug. 10-20—IEEE IconSpace 2015 International Conference on Space Science and Communication. Langkawi Lagoon Resort. Langkawi, Malaysia. See ieeemy.org/iconspace2015
Aug. 26-27—Airline Cost Conference 2015. IATA Geneva Conference Center. Geneva. See iata.org/events/Pages/airline-cost-conference.aspx
Aug. 27-28—International Aerospace Engineering Conference. Vancouver. See iaec-conference.com/#
Aug. 30-Sept. 1—International Aviation Forecast Summit. Bellagio Hotel and Casino. Las Vegas. See aviationforecastsummit.com
Aug. 31-Sept. 2—Airports Council International Latin America-Caribbean World Annual General Assembly 2015. Westin Playa Bonita Panama Hotel. Panama City. See aci-waga2015.com
Sept. 1-4—European Rotorcraft Forum-2015, Technical University of Munich. Munich. See erf2015.dglr.de
Sept. 14—SpeedNews 3rd Annual European Aerospace Raw Materials & Manufacturers Supply Chain Conference. Hotel Palladia. Toulouse, France. See speednews.com/european-aerospace-raw-materials-and-manufacturers-supply-chain-conferences
Sept. 14-16—SpeedNews 16th Annual Aviation Industry Suppliers Conference in Toulouse (AISCT-16). Hotel Palladia. Toulouse, France. See speednews.com/aviation-industry-suppliers-conference-in-toulouse
Sept. 15-16—World Low-Cost Airlines Congress 2015. Business Design Center. London. See terrapinn.com/wlca2015-learn-more
Sept. 15-18—DSEi. ExCeL London Exhibition and Convention Center. London. See dsei.co.uk
Sept. 16-19—Aviation Expo/China 2015. Beijing. China National Convention Center. See beijingaviation.com

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The Case for the LRS-B

BY MICHAEL DONLEY

U.S. AIR FORCE

Michael Donley served as 22nd secretary of the Air Force in 2008-13.

As the U.S. Air Force approaches a source-selection decision on the Long-Range Strike Bomber (LRS-B), it's worth reflecting on how important this decision is for the nation's future military capabilities and the Defense Department's often-maligned acquisition process.

There is a demonstrated need for LRS-B. In both deterrence and warfighting, the U.S. military has long benefited from having aircraft with the range and payload that can penetrate air defenses and hold any target at risk. The bomber's range provides broad geographic coverage; its mix of modern stand-off and shorter-range munitions and stealthy characteristics—for at least the B-2 and future bombers—complicate air defenses and can efficiently deliver precision effects on multiple targets within hours.

Bombers are dual-capability assets used for both nuclear and conventional missions. The bomber force continues to play a critical role in supporting nuclear deterrence, and precision-guided weapons have enabled warfighters to take full advantage of the bomber's large payload. This dual capability makes the new LRS-B a cost-effective investment and a logical place to start leading into modernization of the nuclear triad.

> "We need to commit to this program and stick with it to completion."

The combination of stealth, range and payload—and broad applicability, from supporting special operations forces to conducting strategic raids or sustained campaigns—translates into responsiveness and strategic flexibility for combatant commanders. Past bomber acquisition failures have left today's bomber inventory with only 96 combat-coded aircraft averaging more than 37 years in age. This fleet is too small, too old and dependent on too few of its most capable aircraft, the 20 stealthy B-2s. Recapitalizing the bomber force structure is long overdue.

The acquisition approach is sound. Following the department's cancellation of the Next-Generation Bomber in 2009, I was determined to craft a successful bomber program. Throughout 2010, the Air Force and Defense Department reviewed more than 28 studies conducted since 1995 on long-range strike. Acquisition lessons learned from the restructured KC-X tanker competition and other programs were carried over into LRS-B.

We focused on setting affordable, realistic and achievable requirements up front. We looked at mature technologies from a variety of current programs and made informed trade-offs at the outset to control costs and technical risk. We took a "family of systems" approach, recognizing that the bomber did not have to do everything itself and would be part of a larger joint portfolio of ongoing intelligence/surveillance/reconnaissance (ISR), communications, electronic warfare and weapon programs and capabilities essential to long-range strike and other missions.

All this work culminated in a 2011 classified memorandum, approved by senior Pentagon leadership and signed by Defense Secretary Robert Gates, which outlined details of the new LRS-B program.

Details should remain classified. A notable difference between the tanker and bomber acquisitions is the paramount need to protect U.S. advantages in sensitive stealth-related technologies, which limits public discussion of LRS-B program content. Congressional defense committees have procedures in place for overseeing classified programs and have been authorizing and appropriating LRS-B research and development for several years. Nonetheless, as the source-selection decision nears, now would be a good time to revalidate with Congress what can and cannot be discussed openly about this program.

A disciplined source selection is crucial. The LRS-B is proceeding beneath the umbrella of the Pentagon's "Better Buying Power" initiatives, and both the House and Senate have pending legislative proposals in their defense authorization bills for acquisition improvement. This environment will bring additional scrutiny to how well the Air Force and Defense Department have managed the LRS-B source selection. LRS-B is among several recent acquisition programs emphasizing more deliberate capability trade-offs, more careful use of contract types and streamlined program management. Given the ever-present potential for protest, this program especially calls for an extra dose of discipline and attention to detail in the source-selection decision. The bomber force structure is long overdue for recapitalization. Learning lessons from failed bomber and other difficult acquisition programs, LRS-B has been structured for success.

The nation cannot afford any further delays. We need to commit to this program and stick with it. Moving forward and retaining congressional and industry confidence in the Defense Department's acquisition process now depend on a solid source selection.

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