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ON THE COVER

A Reuters photographer captured Managing Editor for Technology Graham Warwick (center) and Senior Propulsion Editor Guy Norris (right) examining a newly unveiled model for Boeing’s truss-based-wing airliner concept at the American Institute for Aeronautics and Astronautics SciTech Forum in San Diego Jan. 8. Their report begins on page 24.

ON THE COVER

Person of the Year Dennis Muilenburg is reshaping the supply chain, leveraging Boeing’s commercial success to win in defense and aiming to lead in hypersonic air travel. But analysts note that the bold moves the company is making also carry risk. Our profile by Senior Business Editor Michael Bruno and Editor-In-Chief Joe Anselmo begins on page 36. Boeing photo.

Aviation Week publishes a digital edition every week. Read it at AviationWeek.com/swst
PILOT SHORTAGE
Given my 38 years of flying for major carriers, I would like to weigh in on the pilot shortage discussion in a recent Feedback (Dec. 24, 2018-Jan. 13, 2019, p. 6). A college degree does not make a person a better officer or pilot—skill and decision-making abilities do.

As a stark illustration, my 21-year-old son earns $140,000 per year with a signing bonus of $70,000 in Amazon stock—without a costly degree, whereas a commuter pilot starts out at $22,000 per year and is saddled with a huge school-related debt.

We have already lost uncountable skilled, smart, hardworking people to careers outside of aviation, but Lufthansa and a few other airlines have figured out how to attract and keep highly qualified pilots. They employ true ab initio pilots, who then fly for the airline and repay the training costs incurred via payroll deductions.

The airline gains an extra four years of a pilot-in-training's productive skills for their investment; the trainees gain entry into a solid career without the time and cost associated with earning a mandatory higher-education degree.

Bruce Richards, Seattle, Washington

F-15 EAGLE OMISSION?
After reading “Canada Seeks Spending Stability as Fighter Competition Heats Up” (Dec. 24, 2018-Jan. 13, 2019, p. 38) I believe the best aircraft—the F-15 Eagle—was not even mentioned.

In its latest form, either the single- or two-seat versions seem best suited: its two engines and excellent safety record are important for cruising over the vast northern wastelands; it can fit the biggest, most powerful radar array, allowing for the greatest detection ranges against cross-polar threats; and it has the greatest range-payload capability, which is also important for patrolling the northern approaches to Canada.

For use outside Canada, it clearly is the best choice for participating in air-to-ground warfare in a hypothetical coalition air campaign (after the Day One activity by stealth aircraft is complete) such as in the current campaigns in Iraq, Syria and Mali. The aircraft’s only potential drawback is stealth, which is not an important capability for northern border patrol or participation in coalition follow-up air activity in generally permissive environments.

Because it is highly unlikely Canada on its own would be looking to launch Day One penetrating strikes that require stealth, it seems logical for the country to buy 60-80 late-model F-15s followed by a squadron or two of F-35s off a well-proven production line 5-8 years later to serve as a “silver bullet” capability, like the F-117 did for years.

Chris Dierkes, Stratford, Connecticut

RECOVERY TRAINING CAVEAT
In response to “Industry Readies for EASA Upset Recovery Training Mandate” (Nov. 26-Dec. 9, 2018, p. 61), yes, roll reversal can be potentially fatal. And it is important to note that you can unwittingly be trained for it via upset recovery training by flying a training aircraft with an inapt Attitude Indicator (AI) display.

Airline and corporate pilots mostly fly a Sky Pointer AI display. If these pilots are upset-recovery trained with a Roll Pointer AI display rather than with their accustomed Sky Pointer AI display, they could be courting trouble.

The orientation of the pointers in these two AI displays move diabolically opposite to indicate roll. Yet the regulators are for the most part silent regarding this reversed difference. With the European Aviation Safety Agency (EASA) upset recovery training mandate nigh, the FAA will be next. Perhaps this reversed AI difference in controlling an airplane will then be addressed before the NTSB gets involved.

Terry Golden, Minneapolis, Minnesota

REMEDY FOR CREW CONFUSION?
Much has been written about the Lion Air Flight 610 accident on Oct. 29, 2018, including “Lion Air Interim Report Highlights Confusion and Dysfunction” (Dec. 10-23, 2018, p. 24). The Boeing 737 MAX’s maneuvering characteristics augmentation system (MCAS) has received particular scrutiny.

Boeing opted to not modernize the 737 MAX cockpit to include crew-alerting-system (CAS) messages, choosing instead to continue with the legacy warning announcements of the 737 NG.

A simple information message when the MCAS is in angle-of-attack (AOA) pitch-limiting mode might have been enough to clear up the confusion the crew were experiencing over the pitch trim.

In the Gulfstream G650 I fly, the flight-control system (FCS) displays a blue (information) CAS message “FCC AOA Limiting” when the mode is active. Additionally, when the AOA indications have gross miscompari-son, we are alerted by a caution CAS message: “AOA Miscompare.”

Airlines must consider what they are giving up in the human factors advances of modern cockpits when they pressure the OEMs to maintain legacy cockpit standards in the drive for common type standards and the savings in training costs that follow.

Nat Iyengar, Technical Pilot, Jet Aviation Business Jets, Lantau Island, Hong Kong

CVR RECOVERY CONCERNS
Lion Air Flight 610 underscores again the need for timely recovery of a flight recorder—in this case the cockpit voice recorder (CVR). In numerous high-profile crashes, CVRs are never recovered or recovered only after considerable time is lost and/or unnecessary costs are incurred.

This situation can be greatly alleviated by installing dual-combination cockpit-flight-data recovery systems and further enhanced by making one of these recorders deployable. Deployable systems have been available for over 40 years; high-capacity survivable solid-state technology for about 20 years.

David Godfrey, Solana Beach, California

Address letters to the Editor-in-Chief, Aviation Week & Space Technology, 2212 K Street, NW, Suite 210, Washington, DC, 20037 or send via email to: awstletters@aviationweek.com. Letters may be edited for length and clarity; a verifiable address and daytime telephone number are required.
**WHO'S WHERE**

Spirit AeroSystems has hired Jose Ignacio Garcia as senior vice president and chief financial officer (CFO). He succeeds Sanjay Kapoor, who will retire after a transition period. Garcia most recently was vice president/CFO of GE Renewable Energy, Paris.

The National Defense Information Sharing and Analysis Center has named U.S. Air Force Col. (ret.) Steve Shirley as executive director. Shirley, a senior executive service member, had been Air Force commander of counterintelligence, antiterrorism and investigative operations in the U.S., Europe and Asia.

AAR has hired Sean Gillen as vice president and chief financial officer. He joins AAR from USG Corp., where he was vice president and treasurer of the Chicago-based company. Gillen also spent nine years in global industrials investment banking with Goldman Sachs. He succeeds Michael Milligan.

The Aerospace Corp. has hired David W. Miller as vice president and chief technology officer. He had been director of the Massachusetts Institute of Technology space systems laboratory and Jerome C. Hunsaker professor for aeronautics and astronautics.

Intelsat has hired Timothy Schermerhorn as regional vice president for North America.

U.S. Air Force Brig. Gen. (ret.) Wayne Monteith has been named FAA associate administrator for commercial space transportation. He succeeds George Nield, who has retired.

Northrop Grumman Corp. has promoted Lucy C. Ryan to corporate vice president of communications and council member for corporate policy. Ryan joined Northrop Grumman in September 2018 as vice president of enterprise communications. Previously, she was General Dynamics’ director of communications.

Andreas Potzsch has been named DFS Aviation Services managing director. Dirk Mann will take over for Potzsch as managing director of en-route and approach.

Matthew Pfrommer has been elected Cubic Corp.’s vice president of mission systems strategic capabilities. He had served in the Defense Department acquisition corps.

Methods Machine Tools Inc. has promoted Jon Dobosenski to general manager of its new Memphis Technology Center. He had been regional sales manager and has more than 30 years’ experience in the machine tool and manufacturing sector.

Parsons Corp., a national security, intelligence, and infrastructure provider, has merged its federal and infrastructure business units. Carey Smith, former president of the federal unit, will be chief operating officer of the new entity; Mike Johnson, previously president of infrastructure, will be chief development officer; and Virginia Grebbien, lately executive vice president/chief of staff, is now chief marketing officer.

Builder Mortenson has hired aviation construction specialist MacAdam Glinn as general manager for its U.S. aviation business. Glinn had been national aviation director at Skanska and before that was with Parsons Transportation Group.

Grupo Aeroportuario del Centro Norte (OMA) has named Ricardo Duenas CEO. OMA operates 13 international airports in nine states of central and northern Mexico.

London Stansted has appointed Gerry Whyte delivery director of its £600 million ($764 million) airport transformation, one of the UK’s largest airport projects now underway.

The U.S. National Air Transportation Association (NATA) has hired Ryan Waguespack as vice president. He has served on NATA’s workforce development and air charter committees.

Aircraft Propeller Service has appointed Daniel S. Nickolai as vice president of operations. He had been general manager of Paradigm Precision.

Mesa Air Group Inc. has named Douglas Shockey vice president of maintenance. He had been Pinnacle Airlines’ chief operating officer/vice president of maintenance and Silver Airways vice president of technical operations.

Kim Skvorak has joined federal market consultancy Deep Water Point as a principal with their intelligence team. Skvorak is a former deputy chief information officer who has managed projects and contracts for the National Security Agency.

Howell Instruments Inc. has hired Gene Young as director of international business. He had been Airbus Helicopters Inc. senior director of business development.

TECT Aerospace has named Carey Bond, a former executive of United Technologies Corp. and Textron, to its board. Bond was president of Sikorsky Aircraft Corp.’s commercial system and services business before retiring in 2015.

**HONORS & ELECTIONS**

Sherry Lassiter, director of the Fab Foundation, has been recruited to the Airbus Foundation College of External Experts, which consists of five representatives from nongovernmental organizations as well as the aerospace business. Lassiter’s nonprofit organization was spun off from MIT’s Center for Bits & Atoms Fab Lab Program. Its mission is to provide access to the tools, knowledge and the financial means to educate, innovate and invent using technology and digital fabrication.

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

Sikorsky and Boeing have rolled out the SB-1 Defiant high-speed helicopter, built for the U.S. Army’s Joint Multi-Role technology demonstration. The helicopter is expected to fly early this year.

After a two-year delay, Indonesia has resumed paying for its 20% share in development of the KF-X fighter, according to manufacturer Korea Aerospace Industries.

Tupolev completed the first flight of an upgraded version of Russia’s Tu-22M3 bomber, the Tu-22M3M, with increases in range and lethality, on Dec. 28 from Kazan Aviation Plant.

Czech manufacturer Aero Vodochody made the first flight of its prototype upgraded L-39NG jet trainer on Dec. 22, more than two months since its official rollout in October.

Leonardo has flown the first prototype of its M-345 High Efficiency Trainer. The aircraft took to the air from the company’s Venegono, Italy, airfield on Dec. 21.

Saab performed the first flight of the second GlobalEye airborne early warning and control aircraft Jan. 3 from Linkoping, Sweden. GlobalEye is based on the Bombardier Global 6000.

Canada has finalized a deal to acquire 25 used Boeing F/A-18s from Australia to serve as a stopgap until Ottawa chooses a long-term replacement for its similar-vintage CF-18 fleet.

U.S. Air Force Accepts KC-46A

The U.S. Air Force has accepted the first KC-46A Pegasus aerial refueling tanker after manufacturer Boeing agreed to fix, at its own expense, deficiencies discovered in developmental testing. The milestone was years in the making, as Boeing absorbed more than $3 billion in charges on the fixed-price program. The decision will allow four aircraft to be delivered to McConnell AFB in Kansas by late January. Four more will be delivered to Altus AFB in Oklahoma beginning in February for aircrew and maintenance training.

The Air Force had long blocked acceptance over issues with the Centerline Drogue System and the Remote Vision System (RVS). “The Remote Vision System, which allows operators to see refueling planes, and boom actuators, which extend the refueling boom, posed the toughest challenges,” Air Force spokeswoman Capt. Hope Cronin wrote.

Boeing, which had originally argued that a software upgrade to the RVS was outside the scope of the initial contract, implemented a software fix to improve sun glare and shadow visibility. “We have included a software enhancement on the first delivery jets and have agreed on future upgrades as well,” says Boeing spokeswoman Kelly Kaplan.

JetBlue Airways firmed up an order for 60 Airbus A220-300s. Deliveries will begin in 2020 from the new U.S. assembly line in Mobile, Alabama. U.S. low-cost startup Moxy signed a firm order for 60 A220-300s for delivery beginning in 2021. Delta Air Lines increased its landmark A220 order, adding 15 -300s.

U.S.-based Global Infrastructure Partners and its co-shareholders have sold 50.01% of London Gatwick Airport to French company Vinci Airports for £2.9 billion ($3.7 billion).

A second prototype of Indonesian Aerospace’s N219 light twin-turboprop civil aircraft flew for the first time on Dec. 21. Deliveries are expected to begin in 2019.

Startup Boom Supersonic has closed a $100 million investment round to continue work on its Mach 2.2 airliner—now called the Overture. The 55-seat aircraft is planned to enter service in the mid-2020s.

Ireland’s Ryanair has been awarded a UK air operator’s certificate as European carriers move to shore up their post-Brexit operations ahead of the UK’s planned departure from the European Union in March.
The UK government is proposing to expand no-fly zones near airports for unmanned aircraft and increase police powers in response to drone-related disruptions at London Gatwick and Heathrow airports (page 31).

Transport Canada has announced new drone rules that introduce basic and advanced categories of operations, both requiring owners to register their aircraft and obtain a pilot certificate.

U.S. insurance company State Farm has received the first long-term FAA national waiver to fly drones beyond visual line of sight and over people for damage-assessment flights after natural disasters.

SPACE
China's Chang'e 4 probe reached its destination Jan. 3, becoming the first spacecraft to land on the far side of the Moon. The lander deployed the Yutu 2 rover, equipped with a camera and lunar-penetrating radar (page 29).

Ultima Thule, the farthest celestial body yet visited by a spacecraft, appears as a dark reddish “bilobate,” a single object comprised of two large and small lobes, in data transmitted by NASA's New Horizons spacecraft following its Jan. 1 close flyby.

Orbcomm’s 20-year-old FM 16 satellite broke up in orbit on Jan. 1, generating 34 pieces of debris. The U.S. Air Force, which detected the breakup, says there is no evidence of a collision (page 18).

A failed gyroscope has shut down operations of Maxar Technologies’ Earth-imaging WorldView-4 satellite after two years in orbit, far short of its seven-year design life.

OBITUARIES
Herb Kelleher, who founded Southwest Airlines and began a global low-cost airline revolution, died Jan. 3 at age 87. Kelleher practiced law on the U.S. East Coast before relocating to Texas where, in 1967, he and client Rollin King incorporated Air Southwest, Inc. with the idea of offering low-fare, intra-Texas airline service (page 16).

Tony Broderick, a former top safety official at the FAA and aviation safety consultant, died Dec. 30, 2018, in Bealeton, Virginia, following a long illness; he was 75. Broderick joined the FAA in 1976 and in 1978 moved to the regulation and certification division, where he played central roles in several major regulatory initiatives, including extended-range standards, the International Aviation Safety Assessment program and harmonization of U.S. and European regulations. He resigned from the FAA in 1996 in the wake of the ValuJet crash and became a consultant for Airbus and other companies. He retired in 2014.

30 YEARS AGO IN AVIATION WEEK
Our Jan. 16, 1989, cover featured a full-scale model of the Soviet Union’s space shuttle orbiter in a high bay. With the Soviets having flown the “Buran” shuttle in space without a crew two months earlier, planning for a manned mission had begun, and final assembly of a second orbiter was under way, Aviation Week’s Jeffrey Lenorovitz reported from the Baikonur Cosmodrome’s shuttle orbiter integration facility. “Soviet officials acknowledge that their orbiter’s basic design is patterned after that of the U.S. [shuttle],” he wrote. “The similarities begin with the overall configuration and continue to such details as the form and layout of the forward fuselage’s flight deck, middeck and equipment bay, the payload bay configuration, the general philosophy used for the cockpit instrument panel layout and the installation of the reaction control system.” But with the Soviet empire collapsing, the Buran never flew again, and work on two sister shuttles was halted. The vehicle assembly building, whose construction Lenorovitz described as “shabby,” collapsed in 2002, causing multiple fatalities.

Subscribers can access every issue of Aviation Week back to 1916 at: archive.aviationweek.com
WHEN THE TRUMP ADMINISTRATION took power two years ago, it promised big changes that could have a large impact on the country’s aerospace industry. There were four broad areas of concern or promise: trade agreements, tariffs and other disputes with China, U.S. economic growth and defense spending growth. Halfway in, Trump’s impact looks far more muted but with major issues undecided.

Trade agreement concerns quickly became the biggest non-issue, with lots of smoke and little fire. The Border Adjustment Tax, once a centerpiece of administration trade policy, has been consigned to the museum of bad ideas. Talk of the U.S. exiting the World Trade Organization (WTO) vanished. NAFTA is still in place, pending replacement by the U.S.-Mexico-Canada Agreement, which is effectively the same thing. No aerospace industry sourcing decisions have been changed as a result of any Trump administration policies.

The aerospace industry also largely escaped the higher costs imposed by aluminum and steel tariffs, which have not shown up in company financials in a meaningful way. By contrast, in October, Ford Motor Co. announced that it had so far taken a $1 billion profits hit from these tariffs.

Trade actions against individual countries may have damaged international relations, but no aerospace sales were affected by these actions. The one exception is U.S. trade disputes with Canada, but only because Boeing elected to join these disputes. If Canada buys non-U.S. fighters for the first time in half a century, we’ll know the damage here was long-lasting.

Meanwhile, trade growth has resumed. In September 2016, the WTO cut its trade-growth forecast for the year to just 1.7%, the slowest rate since the 2008 financial crisis. That forecast is now 3.9% for 2018, with 3.7% projected for 2019. China trade issues may be another matter. The biggest single commercial aviation market in the world, and the biggest export customer for U.S. aerospace products, continues to occupy center stage. While Trump did not follow through on his threat to impose tariffs of up to 45% on Chinese imports, he did threaten to impose 25% tariffs on $200 billion worth of imports, and China threatened to retaliate.

On Dec. 1, President Donald Trump and Chinese President Xi Jinping declared a 90-day truce. For the aerospace industry, this potential conflict remains the biggest overhang into the second half of the Trump administration, an outlook worsened by the Chinese government’s increasingly hardline stance on relations with the West.

Defense spending is another area of uncertainty. Trump’s promise to boost budgets resulted in a very healthy increase to $700 billion in fiscal 2018, over 10% more than fiscal 2017 and 18% more than the original fiscal 2017 proposal. But growth slowed to just over 2% with fiscal 2019’s $716 billion. And now, there is confusion over whether the fiscal 2020 budget will see shrinkage ($700 billion), another 2% boost ($733 billion) or a solid 5% rise ($750 billion).

None of the recent administration personnel changes nor the Syria withdrawal and partial Afghanistan withdrawal announcements promise good things for defense spending. And Trump recently tweeted that current defense spending levels were “crazy.” Further growth, therefore, looks improbable.

The broader economy is equally complicated. There has been very little change, except that the expansion under President Barack Obama has actually accelerated by a respectable degree under Trump. The problem is that this acceleration is likely the result of unsustainable factors: Big tax cuts (some of which are set to expire), plus higher levels of government spending, have fueled a “sugar high.” The comedown from this rush will be worsened by rising labor costs and interest rates, with commercial jets particularly sensitive to the latter. As a result, the stage may be set for a downturn in the coming year or two, a prospect anticipated by the S&P 500’s 17% drop since September.

Share prices at the three largest U.S. pure-play defense primes sum up the impact of the Trump presidency. Lockheed Martin’s share price hit a high of $363 in February 2018. It has since retreated to $256, as of this writing—almost the same price as when Trump won the election. Northrop Grumman and Raytheon stock trajectories tell an identical story.

These share prices reflect the industry’s new reality: Uncertainty now plays a bigger role than the prospect of growth. China, the defense budget and the broader economy all weigh heavily on the sector as we enter 2019. 

Contributing columnist Richard Aboulafia is vice president of analysis at Teal Group. He is based in Washington.
We celebrate the life of Herb Kelleher and the legendary impact he made on the aviation industry. May Herb’s pioneering spirit continue to live within us all.

Herb Kelleher 1931–2019
A NEW YEAR’S PREDICTION:
2019 will see “big money” finally buy in on aerospace—or decide to leave it for another generation. The chances are 50-50.

No less than U.S. Commerce Secretary Wilbur Ross hopes the money comes. The former banker has become one of Washington’s leading proponents of private-sector-led commercial space. To tempt some of his former business cohorts to the outer space sector, he is hosting a series of summits near the White House for the well-heeled. The first occurred Dec. 12, 2018; the next is set for Feb. 5-6.

Ross is encouraged by the growing interest of major investment banks and institutional investors, but he acknowledges there is a long way to go before Goldman Sachs or Morgan Stanley will bankroll new-space.

“Ventures in space launch, space manufacturing, satellite servicing, space tourism and asteroid mining are on the verge of potentially explosive growth,” Ross says. “But while venture capital continues to support these new endeavors, more traditional financial service participants—big banks and lending institutions—have not been as active. We need to change that.”

The Commerce Department will try to hone metrics and improve financial reporting related to the space sector, including market values and workforce statistics. Wall Street loves data, and Ross and his staff know that the government must provide more and higher-quality data to attract high-powered private investment.

Ross points to SpaceX, which The Wall Street Journal reports is raising $500 million, thanks to a fresh $30.5 billion valuation. That would be about 9% above its roughly $28 billion valuation as of its previous funding round just last April, Morgan Stanley analysts noted in a Dec. 19 alert to clients. It also comes after the Elon Musk-led company reportedly raised $250 million of high-yield debt in November.

“We see SpaceX’s ability to raise capital as key to funding the development of the trillion-dollar space economy,” the analysts say.

Initially, “big money” in aerospace was government-generated. However, that funding source is increasingly unreliable; note that both NASA and NOAA are severely hampered due to the so-called shutdown of parts of the federal government, which makes private funding much more important. In recent years, billionaire founders self-funding their ventures, or venture capitalists from Silicon Valley, followed by token investments from some legacy aerospace and defense prime contractors, have fueled the sector.

But Wall Street, with good reason, has mostly left aerospace to the realm of dreamers with deep pockets because so much remains unproven beyond the business cases of building and flying commercial airliners. In the case of the extraterrestrial sectors Ross has spoken of—space launch and asteroid mining—recent news has not been encouraging.

In late 2018, little-known Bradford Space, which lists itself as a U.S.-owned space systems manufacturer with sites in the Netherlands and Sweden, acquired Deep Space Industries (DSI), once a prominent startup that sought to mine asteroids. By the time of the sale, six-year-old DSI apparently had burned through millions in venture capital on its way to never launching the Xplorer spacecraft, originally eyed by 2020.

DSI’s sale followed the demise of another asteroid-mining pioneer, Planetary Resources, whose assets along with two key executives were tapped last year by ConsenSys, which bills itself as a “blockchain venture production studio.” In January 2018, Planetary Resources launched the Arkyd-6 satellite to demonstrate technology designed to detect water resources in space. It also purports to have completed the world’s first deep-space resource exploration plan to characterize hydrated resources on near-Earth asteroids. Now its efforts will go “to help humanity craft new societal rule systems through automated trust and guaranteed execution,” according to the Oct. 31 announcement.

As deflating as those business exits may be, more could be coming. Space enthusiasts are awaiting a potential shakeout in the space launch and geostationary satellite manufacturing sectors, at the very least.

Big money tends to shy away from such volatility in favor of profitable ventures like large commercial aircraft leasing. To that effect, private equity investor KKR is entering the aircraft lessor market with a $1 billion investment into Altavair toward buying six cargo aircraft. KKR and Altavair AirFinance announced Jan. 3 they will form a long-term partnership to pursue a global portfolio of leased commercial aircraft. KKR also will acquire 50% of Altavair.

Maybe Ross can help traditional financial giants and large investors turn their attention to the heavens. For now, however, their attention and money are staying focused inside the atmosphere. Over the coming year, we should know whether that changes.

A VIATION WEEK & SPACE TECHNOLOGY /JANUARY 14-27, 2019
COMMENTARY

INSIDE BUSINESS AVIATION

WILLIAM GARVEY

ARGUABLY THE MOST UNUSUAL
aircraft manufacturer extant, WACO
Aircraft Corp. recently changed owners,
and the seller, who remains as president,
is clearly delighted.

The Michigan manufacturer hand-builds
the wheeled WACO YMF-5D (see photo), amphibious
YMF-5F and Great Lakes 2T-1A-2 aerobatic aircraft, all
of which are single-engine, tube-and-fabric biplanes.
While no other company has such a product line, what
makes WACO particularly special is that the YMF
traces its roots to the graceful WACOs of the 1930s and
shares its provenance with the citizenry of the U.S. An
explanation follows:

Around 1978, the entity that held the original
Bureau of Air Commerce Type Certificate for the
long-defunct YMF became concerned about any
potential legacy obligations to the existing, aging
fleet. Accordingly, it returned the document and as-
sociated engineering drawings to the FAA, thereby
making those elements part of the public domain.

Later, Dick Kettles, who ran a fixed-base operation
(FBO) at Lansing, Michigan's municipal airport, was
determined to even out his business ups and downs.
His solution was without precedent and not a little
amazing. He went to Washington, copied all the draw-
ings for the YMF, returned to Lansing, built tooling,
rented workers and started production. Anyone could
do the same thing, but the market for resurrected
biplanes from aviation’s “Golden Era” is rather
limited and doesn’t invite competition. The first reborn
YMF flew in 1985, and production deliveries began in
1986.

Mind you, the modern YMFs incorporate hundreds
of improvements over the original, and for those the
company has been awarded supplemental type certifi-
cates, all tied to the original 1935 TC. Since the YMF’s
relaunch, nearly 150 of the FAA-certificated airplanes have been delivered, with more on the way. WACO ac-
quired the TC for the Great Lakes in 2011, 31 years af-
fter that model had ceased production, and delivered 13
of that aircraft by the end of 2018.

Classic craftsmanship—and these planes are flying
jewels—comes at a cost. The wheeled YMF lists for
about $500,000 and the amphib for $650,000, while
the Great Lakes goes for $270,000.

In 1999, the company changed hands and moved 50
mi. southwest to Battle Creek, Michigan. Then, in 2008,
it was acquired by Peter Bowers and his father, Jon.
Under the Bowerses, product improvements and pro-
duction were steady, albeit at a measured pace. As with
most small aviation entrepreneurs, the Bowerses had
finite resources and they chose their projects carefully,
such as creating the amphibian and offering an optional
glass cockpit YMF. Peter Bowers says the company de-
Ivers 6-10 aircraft a year; he expected to close out 2018
having sent eight aircraft to owners the world over.

One of those YMF-5s went to Switzerland and in the
doing helped to open a new chapter in the compa-
y’s history. The buyer-pilot was Dieter Morszeck. He
formerly headed family-owned Rimowa, a European
maker of high-end luggage, best known for its corrugated
aluminum construction—harking back to the
Junkers transports of the 1930s. Indeed, he so admired
the period and style that in 2010 he began a project to
build a Junkers F13, the world’s first metal commercial
passenger aircraft. He went on to fly the experimental
replica in September 2016.

Well-Satisfied Customer
A shared “vintage” value

Now, after selling the luggage company, the 65-year-
old Phenom 300 pilot plans to immerse himself in mat-
ters aeronautical through Dimor Group Inc., an avia-
tion holding firm he established in Fort Lauderdale,
Florida. Its first acquisition occurred last November
with the purchase of WACO from the Bowerses, along
with the adjacent Battle Creek FBO. It plans on ex-
panding the production facility, doubling the payroll to
60 employees and delivering 16 aircraft this year.

“This is a good deal for everybody,” says Bowers,
who continues as president. “There were things I
wanted to do but couldn’t afford.” He says the company
now has the resources to grow and expand its offer-
ings, though he declined to identify exactly what those
“other things” might be.

He noted that today many smaller American gener-
al aviation companies have Chinese owners and says,
“I’m thrilled we did not have to go in that direction.”

And while the WACO company “wasn’t publicly for
sale,” he says, once Morszeck got to fly his YMF, things
started changing. Bowers alluded to that electric “shav-
er ad from years ago when the guy said, ‘I liked it so
much, I bought the company.’” As for his assessment
of his satisfied customer: The new owner is “a vintage
aircraft guy.”

AviationWeek.com/awst

William Garvey is Editor-in-Chief of Business & Commercial Aviation
There are probably more anecdotes about Herb Kelleher, who died Jan. 3 at age 87, than any other airline executive. But it is doubtful the most famous one is accurate. It is about a meeting in 1967 between Kelleher, the lawyer, and Rollin King, his customer. King allegedly drew a triangle on a paper napkin to show the initial Southwest route network between Dallas, Houston and San Antonio. Southwest was the airline he wanted to set up. “Never did it,” King said in a 2007 interview about the alleged drawing. “But it was a hell of a story.”

Most of the other anecdotes are probably true, and many in the industry have one to tell. The surprising hugs, and sometimes kisses, for strangers (with Kelleher laughing, “You should have seen your face!”). The Wild Turkey bourbon stories and the chain smoking; both aspects of the man are well-documented. The lost wrestling match over advertising rights for a slogan. The humor: “Because I am unable to perform competently any meaningful function at Southwest, our 25,000 employees let me be CEO,” he told a Washington hearing ostensibly about FAA funding.

What a pleasant exception in an industry full of big-ego, humorless executives.

More important, if there was ever an industry executive deserving of the accolade of having fundamentally changed air transport, he comes the closest. There are two main reasons for his success.

The first is not specific to airlines or the industry. If you treat employees well, the likelihood they will deliver and be nicer to customers is very high. Kelleher was a master at employee relations. It was not so much about the parties, at headquarters or elsewhere, where he showed up riding a Harley Davidson and took center stage the minute he entered a room. It was about empowerment. Decades before other businesses recognized it as a good thing that mostly is not misused by those empowered and helps improve motivation, performance and customer service, Southwest was avant garde. It certainly helped limit labor disputes, though successors never reached the level of employee appreciation he enjoyed. Southwest’s track record of relatively few labor disputes is also due to some of the industry’s highest wages.

The second is specific to airlines. Michael O’Leary, who considered Kelleher a role model and visited him early in the Ryanair years to pick up ideas, summarized it: “Herb was the Grand Master Yoda of the low-fare airlines. He was the leader, visionary and teacher. Without Herb, there would be no Ryanair and no low-fare airlines anywhere.” O’Leary is widely credited with transforming the European airline industry two decades after Southwest started up. But unlike King and Kelleher, he was no true innovator. And it is probably hard to find an airline CEO who treats his people worse than O’Leary.

That’s how high the Kelleher bar has been set.

The aviation world is full of praise for the legendary Southwest CEO these days, and rightly so. Some nuances should be added, nonetheless. The original idea to set up a low-fare airline in Texas was King’s, who also claimed Kelleher was initially skeptical.

That Southwest started flying (four years after being incorporated) was indeed Kelleher’s achievement to a large extent—he was the lawyer fighting the rules of the prederegulation U.S. airline industry. Not to mention the competitors that tried, at almost all cost, to keep the airline on the ground. Kelleher became chairman only in 1978, the year the U.S. airline industry was finally deregulated. Four years later, he was CEO, a position he kept for 19 years. He retired as chairman in 2008.

Southwest clearly started out as a low-fare airline, and the tactics it introduced are still viable tools: high aircraft utilization, quick turnarounds, a single fleet and an efficient network, the logic of which is based on direct services instead of hubbing. But Southwest is no longer the airline it used to be. The U.S. industry is made up of the big three legacy airlines and their regional affiliates, Southwest, Alaska Airlines, JetBlue Airways and the ultra-low-cost carriers. Southwest is not really low-cost anymore; its unit costs have been rising faster than unit revenues for some time. And its customers would not always consider it a low-fare airline as well.

Notwithstanding O’Leary’s praise of Southwest’s role in the sector, the industry has long deviated from the model. Some airlines have gone ultra-low-cost, others have been proven right that higher levels of service and more complexity is sometimes justified. JetBlue even introduced large regional jets, a platform from which it can now jump off to operate Airbus A220s.

On the other hand, the spirit of aiming at low costs has sunk deeply even into the legacy part of the industry, a consequence of Kelleher’s achievements.
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**COMMENTARY**

**LEADING EDGE**

**GRAHAM WARWICK**

**FLYING IN FORMATION WITH A**

space telescope, the starshade occulter promises to enable high-contrast imaging of exoplanets by blocking out the light from the target star. None has ever flown in space, but NASA has begun an effort to mature the technology quickly and sufficiently enough to be considered by the 2020 Decadal Survey of astronomy and astrophysics.

Launched in September, NASA’s S5 project aims to raise the starshade technology readiness level (TRL) to 5 by 2023, with a plan “to be as ready as we can be within 1-2 years to enable future exoplanet missions,” says Gary Blackwood, manager of NASA’s exoplanet exploration program. The survey committee will complete its report in 2020, so time is short.

The S5 project puts the starshade on the path previously taken by the coronagraph, an instrument for direct imaging of exoplanets that is to fly on the Wide Field Infrared Survey Telescope (WFIRST) planned for launch in the mid-2020s. Recommended by the 2010 Decadal Survey, WFIRST will follow the James Webb Space Telescope, now planned for launch in 2021.

A rendezvous with WFIRST is one of two starshade missions up for consideration by the 2020 Decadal Survey (AW&ST Oct. 29-Nov. 11, 2018, p. 68). The other is HabEx, the Habitable Exoplanet Explorer—one of four large space telescope missions NASA is proposing to the survey committee.

Where a coronagraph is a mask that suppresses starlight within the telescope, a starshade is an external occulter that suppresses the target star’s light before it enters the telescope. Compared with a coronagraph, a starshade has a wider field of view and can allow the telescope to see planets closer to their star.

But developing a starshade will be an enormous technical challenge, made more difficult because such a device cannot be tested on Earth at full scale. The HabEx starshade would be 52 m (170 ft.) in diameter, but stationed 72,000 km (45,000 mi.) away from the telescope—a geometry that can be replicated only at small scale on the ground. Performance will have to be validated by analysis and modeling based on subscale ground tests.

NASA’s requirements are exacting. For formation flying, the telescope will have to sense the starshade's lateral position to within 30 cm (12 in.) and control it to within 1 m. The contrast target is 10^{-10}, both narrowband and broadband. And sunlight scattered around the edges of the petals must have a visual magnitude of less than 25.

But the most exacting requirements are mechanical. The starshade must fold up into a package that fits within the launch-vehicle payload fairing, then reliably unfurl in space while maintaining extraordinarily tight dimensional requirements.

The starshade is an opaque solid disk surrounded by shaped petals. Diffraction around the edge of a solid disk would produce a bright central spot in the telescope: The petals cause destructive diffraction that cancels out the light from the edges.

To work as designed, the starshade petals must be fabricated to a prelaunch dimensional accuracy of ±70 microns and, once deployed, must maintain an on-orbit stability of ±80 microns. The petals must deploy with a position accuracy of ±300 microns and maintain position on orbit to within ±200 microns.

The work required to raise formation-flying maturity to TRL 5 is complete and pending review, but achieving the mechanical performance will take the longest. NASA is driving to achieve TRL 4 in the near term, in time for the Decadal Survey, followed by risk-reduction to reach TRL 5 by 2023.

To help achieve its goals and ensure the starshade can be considered by the survey committee by 2020, NASA has launched the Starshade Science and Industry Partnership (SIP) to bring together interested parties in academia and industry in the U.S. and internationally, to help overcome the technical challenges as quickly as possible.

Activities will include a technology and science working group to identify innovations that could solve starshade challenges and small-business contracts to work on key technologies. The SIP kicked off in December and will run to November 2020. The race is on to make the starshade a contender for the next step in the search for life outside the Solar System. ☄️

**Starshade Targeted**

Starlight occulter offers key to **imaging exoplanets**

AVIATION WEEK & SPACE TECHNOLOGY/JANUARY 14-27, 2019 17
Orbital Debris Count Grows

Cause of Orbcomm satellite breakup under investigation

Aviation Week. “The most likely scenario at present is a collision with some type of space debris . . . smaller than what the Air Force monitors.”

Initial assessments by The Aerospace Corp., which runs the Debris Analysis Response Team for the Air Force’s Combined Space Operations Center, indicate that a relatively low-energy breakup, more akin to a spacecraft battery explosion than a debris impact, was responsible for the breakup.

“We have orbit data from about 20 of the 34 fragments,” Roger Thompson, senior engineering specialist with The Aerospace Corp.’s Center for Orbital and Reentry Debris Studies, tells Aviation Week. “[The fragments] are confined fairly close to the original orbit of the Orbcomm satellite, which means that it was what we consider to be a low-energy breakup.”

The trackable fragments all have the same perigees as the parent satellite’s orbit—488 mi. (785 km) above Earth—and apogees ranging from 621-746 mi. “There was enough energy to kick them into a higher orbit,” Thompson says. “We think [the breakup] was a little bit directional because all the pieces we’ve looked at so far have higher apogees. In a collision, you’ll get fragments that go high and a few that go low, and we’re not seeing any that have gone lower. That’s why we are leaning toward some kind of internal energy source as the reason for the breakup,” Thompson says.

It is possible a tiny, untracked fragment of debris hit the spacecraft, knocking off pieces of the satellite without changing the orbit, adds Ted Muelhaupt, associate principal director of The Aerospace Corp.’s Systems Analysis and Simulation subdivision.

The debris, like the original satellite, is orbiting at a 45-deg. inclination relative to Earth’s equator. Early analysis indicates the fragments do not currently pose a collision risk to other spacecraft.

Spontaneous breakups of spacecraft occur on average about four times a year, mostly explosions of old, Russian-made upper-stage rocket bodies, which generate far more debris than the Orbcomm FM 16 satellite.

The remains of Orbcomm FM 16 join the 22,000-24,000 trackable objects in Earth orbit, of which only about 1,800 are active satellites. Extrapolate from the number of observable but not trackable objects, and the orbital garbage heap grows to some 500,000 objects that could damage or destroy operational satellites. “There is a huge gulf between what we’re tracking and hopefully avoiding, and what we think will damage you,” Muelhaupt says.

The Aerospace Corp. hopes Orbcomm will share any additional telemetry that could shed light on the cause of the breakup, but the company has no obligation to do so. “Maybe they will be forthcoming, and maybe they won’t. It is their satellite, their company. They can decide what information to release,” Thompson says.

Even if Orbcomm wanted to share telemetry data, there is no system in place to do so. A U.S. policy directive, signed by President Donald Trump in June 2018, is intended to establish a civilian space traffic management agency but has not yet been implemented. Among the issues being debated is whether satellite operators should be required to meet a debris-mitigation standard. “We’ve shown that the probability that you will successfully execute your post-mission disposal plan is actually a pretty important number,” says Muelhaupt.

Protecting and managing the space environment around Earth has taken on fresh urgency due to an expected surge in the number of satellites. OneWeb is preparing to launch the first 10 of a 600-900-member broadband constellation. Last December, China launched a prototype for an initial 156-member internet-via-satellite network. SpaceX has approval to operate some 12,000 satellites for its Starlink broadband system.

“These very large constellations represent a step-change in the environment just about any way you look at it, from the number of launches, the number of objects, the size of the constellations,” says Muelhaupt. “If you apply what have been the historical rules, you end up with lots of collisions and breakups and an untenable debris situation. If we don’t change what we’re doing, we’re going to make a really big mess fairly soon.”

Irene Klotz
Monitor competition with timely announcements from airlines, aviation suppliers and manufacturers, including aircraft orders & transactions.

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In the days after its final predeployment test launch, Russian media portrayed the introduction of the new weapon as a technological and strategic coup over American competitors, rivaling the launch of the Sputnik satellite in 1957. The narrative spun by Moscow is clear: As the U.S. research community dawdled for decades on hypersonic technology, Russia's aerospace industry overcame a series of setbacks and triumphed.

"The Americans tried to create something similar, but they failed," wrote Dmitry Kiselyov, director general of the state-run Russia Today news organization in a Dec. 30 commentary. Kiselyov's article does not elaborate, but he is likely referring to DARPA's Falcon program, canceled in 2013 after failing to complete a successful test by a hypersonic boost-glide vehicle. It is worth noting that the lack of details released so far by the Russian government makes it difficult to directly compare Avangard with Falcon, which was a highly sophisticated vehicle designed to achieve simultaneous breakthroughs in the endurance, guidance and manufacturing of a hypersonic weapon.

The Avangard test, however, highlights the looming threat facing NATO, with Russia now boasting an ability to launch a limited strike by a conventional or nuclear weapon designed to avoid existing defenses that are optimized against ballistic missiles such as the recently introduced Aegis Ashore system in Eastern Europe.

Images televised in Russia of the Dec. 26 flight test show the Avangard enclosed within a fairing atop an ICBM launched from the Dombarovsky site on Russia's southern border near Kazakhstan, according to a statement by the Kremlin's press office. The most direct route between the launch and landing sites spans about 3,800 mi. over Siberia. If boosted by an ICBM, such as the SS-19 or the future Sarmat, the Avangard is expected to have effectively "unlimited" range, although the details of its maneuvering characteristics and ability to survive the stresses of hypersonic flight are unknown.

The Russian military plans to deploy the first regiment equipped with the Avangard system at Dombarovsky in 2019, Putin said Dec. 26. The deployment is part of a wider effort by Russia to field a new class of "super weapons" designed to evade the U.S. military's missile defenses and strategic deterrents. These include the longer-range Sarmat ICBM, the air-launched Kinzhal missile, a nuclear-powered cruise missile and an unmanned, nuclear-powered submarine known by the Russian code name Status-6.

Of all the new capabilities, however, the rapid development of Russian and Chinese hypersonic boost-glide vehicles has drawn the most dramatic reaction by the U.S. Defense Department. Russia, in particular, has been involved in hypersonic research for decades. During friendlier relations with the U.S. in the 1990s, Russian researchers teamed up with NASA to perform a series of record-breaking hypersonic flight tests using an air-breathing vehicle. The experience from that program led NASA to develop and test the X-43A supersonic combustion ramjet, or scramjet, early in the last decade.

Over the last 10 years the Russian and U.S. programs have diverged. The project that became the Avangard was first disclosed as "Object 4202" by Russian officials in 2011. Russia reportedly has conducted a series of flight tests with glide vehicles developed under the Object 4202 program, but only the last two tests were successful.

Last March, Russian President Vladimir Putin reidentified the weapon as Avangard and explained its purpose in a televised address. Its ability to maneuver at speeds over Mach 20...
is the Avangard’s most important capability. “This makes it completely invulnerable to any means of air and missile defense,” Putin said.

The current state of hypersonic weapons capabilities can be overstated. DARPA has performed two tests of an advanced hypersonic boost-glide vehicle that resulted in failure. The U.S. Army, meanwhile, has had more success with the Advanced Hypersonic Weapon (AHW) demonstrator, a derivative of a 40-year-old concept tested by Sandia National Laboratories in the early 1980s. Although more limited than DARPA’s concept, the AHW proved successful in a 2011 test flight, but failed in a 2014 follow-up.

The Navy tested another version of the AHW in 2017, scored as a successful flight. All three services are now developing a weaponized version for deployment by the Air Force and Army in 2021 or 2022, with the Navy following soon after. The Air Force and DARPA, meanwhile, also continue to develop more advanced hypersonic weapons.

Adapting U.S. missile defenses to counter the hypersonic threat could take longer. The Missile Defense Agency launched a Hypersonic Defense program in 2017, with a near-term focus on adapting existing terminal phase interceptors for point-defense against hypersonic missiles. But the challenge of a successful intercept at hypersonic closing speeds in the terminal phase is extreme. The undersecretary of defense for research and engineering, Mike Griffin, a former hypersonic vehicle scientist, explained the difficulty in public remarks on Dec. 13.

“The terminal area is not where you undertake the defense against a hypersonic [missile],” Griffin told an audience at a National Defense Industrial Association (NDIA) event. “There’s too many maneuvering G’s available to the threat for us to have high confidence in being able to go after it. So you have to get it in cruise.”

A cruise-phase intercept requires tracking a hypersonic missile at ranges far beyond the ability of terrestrial radar. The U.S. operates missile-warning satellites in geostationary orbit, but those sensors are not designed to track an object moving at hypersonic speed within the Earth’s atmosphere. That challenge is why Griffin has called for development of a Space Sensor Layer, a constellation of satellites in low Earth orbit to detect and track a hypersonic missile through the cruise phase. Griffin acknowledges it could take several years before the Space Sensor Layer is operational. “I think we will have a workable defensive capability by the middle of the decade,” he says.

Another important piece of the U.S. hypersonic defense strategy is to develop a credible deterrent. As offensive hypersonic weapons transition from development to production, the Pentagon is laying the groundwork to support an industry that is capable of mass-producing hypersonic weapons.

Griffin has called for amassing a stockpile of hypersonic missiles numbering in the “thousands,” but no government or company has produced more than a handful of such vehicles.

So far, Lockheed Martin has won the majority of hypersonic weapons contracts. Its Missiles and Fire Control division is developing the Air-Launched Rapid Response Weapon (ARRW) and the Space division is integrating the AHW-derived Hypersonic Air-Breathing Weapon Concept (HAWC). But senior defense officials still hope to avoid creating an industrial monopoly for hypersonic weapons. “I personally would not want us to depend on one single industrial chain. We need multiplicity and redundancy,” Griffin says.

As hypersonic glide vehicles must survive in temperatures of 2,000°C (3,600°F) for long periods during cruise, they are made using exotic composite materials that are difficult to manufacture. To scale up production, a huge investment is necessary to create the infrastructure required to build such sophisticated weapons. At the same time, the Defense Department is unwilling to award long-term production contracts until the technology matures.

Pat Shanahan, the incoming acting secretary of defense, is aware of the problem. Answering a question from the Aviation Week Intelligence Network at the NDIA event, the then-deputy defense secretary explained how he hopes to rapidly create a sustainable, competitive industrial base that can produce new weapons in large quantities within a few years. “I’d love to build the right facilities and then turn the keys over to someone to manage,” he said. “It takes the risk of buying into a business out of the equation if the government takes on the right role of capitalizing infrastructure.”

Unlike the current model for fighters and some munitions, the Pentagon wants continuous competition during production. “It’s just healthy,” Shanahan says. “Instead of a winner-take-all [approach], how do you build that ecosystem that [sustains] competition? It’s the only way to get good.”

Russian President Vladimir Putin observes Avangard launch from the National Center for Defense Management in Moscow.
Top U.S. Hypersonic Weapon Program Facing New Schedule Pressure

FUNDING, TECHNICAL SLIPS DELAY ARRW MILESTONES BY MONTHS

MDA TO KICK OFF PROTOTYPING PHASE FOR SPACE SENSOR LAYER

Steve Trimble and Lee Hudson Washington

The cost, timing and critical risks of the U.S. military’s plans to counter Russia and China’s new hypersonic weapons are emerging from secrecy. As the Missile Defense Agency (MDA) begins prototyping components of a broad new hypersonic surveillance and defense architecture, the U.S. Air Force’s two hypersonic weapons programs launched last year are expected to achieve operational status within two years, despite technical problems slowing an associated program.

The Air-Launched Rapid Response Weapon (ARRW) is the U.S. military’s most advanced reply to Russia’s ground-launched Avangard in the near term. Building on DARPA’s Falcon and Tactical Boost Glide (TBG) programs, the ARRW is expected to become the world’s first air-launched, maneuvering hypersonic glide vehicle with a high lift-to-drag ratio. The Air Force says the ARRW “program is on track” with “no significant deviations from original acquisition strategy and baseline,” according to a mandatory report recently sent to Congress.

In August, the service awarded a $480 million contract to Lockheed Martin Missiles and Fire Control to begin developing the ARRW, but the total cost is $850 million, the Air Force says.

The program may be on track, but it is facing schedule pressures. A predecessor for the ARRW, the Air Force says, but is also running behind. The ARRW’s high lift-to-drag design remains unproven. The Air Force is relying on the TBG to prove that a wedge-shaped glide vehicle can survive the extreme heat of a hypersonic cruise phase, which DARPA’s previous Falcon program failed to achieve in two flight tests. But the first flight tests for the TBG program also are running behind. Citing unspecified “technical challenges,” DARPA has pushed back the flight test from late June to late December this year, the Air Force says.

As the unproven ARRW design moves forward, the Pentagon also is investing in a lower-risk alternative. The Air Force inherited the conical glide vehicle of the air-launched Hypersonic Conventional Strike Weapon (HCSW) from the Army’s ground-launched Advanced Hypersonic Weapon program, which spawned a common glide-vehicle design shared with the Army’s ground launchers and the Navy’s submarines.

The Air Force awarded Lockheed Martin Space a $928 million contract last April to integrate the HCSW on a B-52, but the service’s independent cost estimate is $1.4 billion, the report shows. The first all-up-round test for the HCSW is slated to be completed by late December 2020 and so far appears to be on track. A preliminary design review is set for late June, and a critical design review is planned by late March 2020.

As the Air Force focuses on the ARRW and HCSW near-term, development continues on a supersonic combustion ramjet engine and a waferider-shaped airframe under a long-term effort called the Advanced Full-Range Engine (AFRE) and the Hypersonic Air-breathing Weapon Concept (HAWC).

Hypersonic technology has moved from a niche interest into the acquisition mainstream. As new offensive weapons emerge, the MDA is taking the lead in constructing a vast new architecture to detect, track and intercept hypersonic missiles. The ability of hypersonic glide vehicles to maneuver at the top of the atmosphere poses a difficult problem for current defenses designed for ballistic threats with predictable trajectories.

The MDA plans to kick off a prototyping stage for a new Space Sensor Layer (SSL) of surveillance satellites in low Earth orbit with an industry day Jan. 15. The SSL will explore the detection of hypersonic glide vehicles coasting at the top of the atmosphere.

The MDA is reviewing a vast range of hypersonic defense proposals. In September, the agency awarded contracts to eight companies to produce 21 white papers covering nearly every conceivable approach to defeating an attack by hypersonic missiles. The papers will inform the MDA’s development strategy, which is likely to promote development of several different approaches.

These include a new family of intercepter missiles called SkyFire proposed by Raytheon; hypervelocity projectiles designed by General Atomics, Boeing and BAE Systems; a laser gun offered by Boeing; and electronic attack systems conceptualized by Northrop Grumman, L3 Technologies and Lockheed. Lockheed also has proposed a full range of new interceptors, including a space-based system, an air-launched missile and the “Valkyrie” for terminal hypersonic defense.

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Source: U.S. Air Force Report to Congress
A VIATION WEEK & SPACE TECHNOLOGY /JANUARY 14-27, 2019

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Boeing Refines Truss-Braced-Wing Airliner Concept

SUCCESSFUL WIND TUNNEL TESTS COULD CLEAR THE WAY FOR TEST AND DEVELOPMENT AS A FULL-SCALE X-PLANE

BOEING IS WORKING ON HYBRID-ELECTRIC-POWERED VERSION UNDER NASA CONTRACT

Guy Norris and Graham Warwick San Diego

As part of its continuing quest to develop technology for next-generation, highly efficient single-aisle designs, Boeing has unveiled a refined swept-wing, faster version of its unconventional Truss-Braced Wing (TTBW) concept.

Although the company has been evaluating the high-set-wing TTBW design since 2010, the newest iteration unveiled at the American Institute of Aeronautics and Astronautics Sci-Tech conference in San Diego is potentially the closest yet to a commercially viable 737-size future product. Originally designed with an unswept wing to cruise at a fuel-saving speed of Mach 0.75, the new configuration has been optimized around a 20-deg. swept wing to enable a higher Mach 0.8 cruise speed more typical of current jet airliners.

Developed under the Boeing and NASA Subsonic Ultra Green Aircraft Research (SUGAR) program to study new configurations for ultraefficient airliners that could enter service in the 2035 time frame, the TTBW configuration has an increased-span, high-aspect-ratio wing to minimize induced drag. The reduced-thickness-ratio wing, which lowers form drag and transonic drag in the cruise, is braced by trusses to minimize the weight penalty of the longer span.

“In the previous design, the wing and truss were kind of sitting on top of one another. Because of the configuration change for the higher Mach number, however, the wing has come forward,” says Boeing TTBW program manager Neal Harrison. “The major thing we learned was when we separated those two, we were able to take advantage of the truss from an aerodynamic standpoint more than we had previously.”

The redesigned truss has increased chord at the fuselage, forward sweep at the trailing edge and tapers toward the junction with the wing. A small jury member connecting the truss to the wing has been moved farther outboard, closer to its junction with the wing. “The truss will now generate lift. On the previous generation, if you lifted on the strut, it would put load into the lower surface of the wing. By decoupling those, we can do aerostructural and aerodynamic optimization to maximize performance,” says Harrison.

Despite the sweep increase, the wing retains the same narrow chord, planform and 170-ft. span of the previous design. With an aspect ratio of 19.6, the location of the wing fold also remains in the same position, just outboard of the truss attachment point. The wing-fold feature is designed to enable the TTBW to use smaller gates, like those used by the 118-ft.-span 737.

“The prime focus of the program remains to validate the aerodynamic efficiency of the configuration, and we are moving into the validation phase with wind tunnel testing,” says Harrison. “We expect it to have an 8-10% improvement in fuel burn over a conventional cantilevered wing design, but we are still validating that,” he adds. “The upcoming wind tunnel tests will give us a real number.”

Following the completion of high-speed line definition, the wind tunnel campaign is due to begin early this
year with a Mach 0.8 high-speed test at the NASA Ames 11-ft. transonic facility. The work will continue with a low-speed test later in 2019 at the 14 X 22-ft. subsonic tunnel at NASA Langley.

Successful wind tunnel tests could potentially clear the concept for further test and development as a full-scale X-plane. Under NASA’s original Ultra-Efficient Subsonic Transport (UEST) plan, outlined in the New Aviation Horizons flight demonstration initiative within NASA’s budget request for fiscal 2017, a series of UEST X-planes were due to fly from fiscal 2023 onward. However, NASA did not receive the required funding and is now considering an alternate strategy to accelerate testing of large-scale hybrid-electric propulsion demonstrators.

Although Boeing proposed a full-scale TTBW X-plane demonstrator for UEST based on a modified MD-80 fuselage powered by conventional turbofans, the configuration is propulsion-agnostic and could be adapted to a hybrid-electric propulsion system. To this end, Boeing is also studying a hybrid-electric-powered version of the TTBW under contract from NASA. This aircraft has a series/parallel partial-hybrid architecture based on Rolls-Royce Liberty Works’ Electrically Variable Engine (EVE) geared-turbofan concept, also developed for NASA.

EVE has a 1.5-megawatt electric motor/generator mounted on the shaft between the three-stage low-pressure booster compressor and the reduction gearbox driving a variable-pitch fan. A battery powers the motor to taxi the aircraft and boosts the turbine for takeoff and climb, allowing for a smaller engine.

During takeoff and climb, the battery also powers an aft motor that drives a boundary-layer ingestion (BLI) fan mounted in the tail. This ingests the slow-moving airflow over the fuselage and reenergizes the wake, reducing drag. In cruise and descent, the generator drives the BLI fan and recharges the battery.

Boeing’s analysis indicates hybrid-electric propulsion could potentially reduce fuel burn and carbon emissions for the 3,500-nm design mission by 4.5% under the conventionally powered TTBW, while nitrogen-oxide emissions could be reduced 19% and airport noise by 1%. The study for NASA concluded that a hybrid-electric flight demonstrator would be a “natural spiral of a TTBW X-plane concept.”

The study for NASA concluded that a hybrid-electric flight demonstrator would be a “natural spiral of a TTBW X-plane concept.”

**Check 6 Graham Warwick and Guy Norris report from this year’s AIAA SciTech conference: AviationWeek.com/podcast**
From a flight-rate perspective, SpaceX’s 2019 manifest will closely match what it achieved in 2018, with one key difference: This year, the company intends to enter the human spaceflight business, a market that has been closed to the U.S. since the end of the space shuttle program in 2011. “We will be ready,” says SpaceX President and Chief Operating Officer Gwynne Shotwell. “It’ll be very different flight, a very different launch for us, for sure.

“You kind of want it to not be different,” in order to follow the established processes and procedures that have proved so successful in the past, Shotwell says. “But putting people on top, by definition, will change that. Even if [the process] is not physically changed, it will change people emotionally, and so they may do things differently.”

So far, four NASA astronauts—Robert Behnken, Douglas Hurley, Michael Hopkins and Victor Glover—have been assigned to fly aboard SpaceX Dragon 2 capsules, which are upgraded, crewed versions of the Dragon cargo ships that have been launching supplies to the International Space Station (ISS) since 2012. A second spacecraft, the CST-100 Starliner, is under development by Boeing.

The astronauts meet with SpaceX workers for technical briefings and to stress that human lives are at stake. Employees have requested this. “They wanted to put pictures of the astronauts on the electronic work orders as a constant reminder. People are preparing themselves,” says Shotwell.

Following an unmanned flight test of the Dragon 2 slated for February, SpaceX plans to launch Behnken and Hurley on a shakedown flight this summer. If successful, the company could be ready to begin operational crew ferry flights before the end of the year. NASA’s contract with the Russian space agency to fly crew to the ISS expires in early 2020.

Between cargo runs to the ISS, two Dragon 2 flight tests, an in-flight-abort demonstration and possibly a crew-rotation mission, SpaceX is looking to fly as many as seven missions for NASA this year. In 2018, SpaceX flew three ISS resupply missions and launched its first high-value NASA science mission, the Transiting Exoplanet Survey Satellite.

SpaceX last year also conducted two missions for U.S. military organizations, including the first of five planned GPS III launches. In 2019, a second GPS III is expected to fly on a Falcon 9, and a Falcon Heavy is slated for a U.S. Air Force Space Test Program launch.

As in 2018, when SpaceX achieved 21 flights—more than the combined total of Russia’s military, civil and commercial launches and 2.5 times more than United Launch Alliance, its closest U.S. competitor—the bulk of SpaceX’s 2019 manifest will be commercial flights, beginning with a launch in January to put the last 10 satellites of the 75-member Iridium Next constellation into orbit.
The 2019 Falcon 9 lineup includes two launches to dispatch privately owned spacecraft to the surface of the Moon and the first operational Falcon Heavy mission, which will loft the Arabsat-6A communications satellite.

SpaceX also will tackle some of its own ventures in 2019. A batch of first-generation SpaceX Starlink broadband satellites—the company declines to say how many—is expected to head to the launchpad in the first half of 2019, following the flight tests of two prototypes last year. The Federal Communications Commission in November cleared SpaceX to operate an expanded network of about 12,000 satellites for wireless internet access. The approval starts a six-year clock for SpaceX to launch at least half the network or risk having the size of the constellation capped at the number of spacecraft in orbit by 2024.

“Starlink satellites were designed to fly on a Falcon 9, so we can fly a lot of them,” Shotwell says. The Falcon 9 Block 5 is meant to be used 10 times with minimal refurbishment between flights, and so far one of those boosters has been flown three times. “I believe we will spin the design of the Starlink bus the way we have spun the design of Falcon 9. We start with a minimum-capable product, [work on it] and enhance the design. . . . The initial buses won’t have the same capability that we plan for the final spin.”

SpaceX has not yet started selling Starlink services. “I believe there will be some advance orders . . . but [for now] we’re really focused on the technology,” Shotwell adds.

Starlink launches are expected to become a substantial portion of the Falcon 9 manifest in 2020. Rocket launches and planned satellite services already have pushed the value of privately owned SpaceX to a reported $30.5 billion, pending closure of the company’s latest $500 million round of financing. But CEO Elon Musk is quick to point out that SpaceX’s raison d’être is to develop a transportation system to Mars.

Toward that lofty ambition, SpaceX is preparing for its first trials of a Starship test vehicle (previously known as the Big Falcon Rocket, or BFR) at its Boca Chica, Texas, facility. Originally the planned site of a SpaceX commercial spaceport, the facility, near Brownsville, Texas, has taken on a futuristic landscape with a retro-looking stainless steel prototype Starship upper stage that is being assembled for low-altitude, so-called hopper tests set to begin in a month or two. The three-finned spaceship resembles the rocket pictured in the 1954 comic book Adventures of Tintin: Explorers on the Moon.

The prototype will be powered by three methane-fueled Raptor engines, which are a blend of development and operational parts, according to Musk. The first hopper engine is nearing completion in California and should be ready to be test-fired next month. The point of the hopper tests, which are intended to boost the vehicle to an altitude of no higher than about 3 mi. (5 km), and then land vertically, are to test the heat shield, aerodynamic control surfaces and other systems.

SpaceX initially planned to launch the Falcon 9 and Falcon Heavy from Texas but now expects that site to be dedicated to Starship testing and possible orbital launches. “Before we got [Kennedy Space Center Launch Complex] 39A, we thought we would need another launch site, but the Eastern Range 45th [Space Wing] has figured out how to be very efficient, and we’re turning launches around in less than two-week periods. The capability is there, so I don’t think we need to put Falcon 9 and Falcon Heavy in Brownsville. We’re really focused on [establishing] the Starship there,” Shotwell says.

Eventually, SpaceX intends to retire the Falcon 9 and Falcon Heavy and fulfill all its launch service contracts with the Starship. But the company is in no rush to stop production or scrap the fleet. It intends to build 11-12 new Falcon first stages in 2019, about the same number it manufactured last year. “We’re going to keep building Falcon 9s and Falcon Heavies until we are past the demand for new vehicles,” says Shotwell. She notes that the Starship will basically render the Falcon 9 and Falcon Heavy obsolete, “but we’re going to keep flying them until all our customers want to fly on the new system.”

### How Will ArianeGroup Solve Its Launch-Rate Quandary?

#### WEAK DEMAND FORCES ARIANE 6 LAUNCH-RATE REDUCTION

#### ECONOMIES OF SCALE ARE AT RISK

**Thierry Dubois** Lyon

Given the recent big changes at ArianeGroup, new CEO André-Hubert Roussel, who took the helm Jan. 1, is being immediately tested by numerous challenges. In November, the manufacturer of Ariane launchers announced a plan to cut 2,300 jobs from its 9,000-strong workforce over 4-5 years, it reduced the Ariane 6’s planned launch rate because of a lack of orders, and then-CEO Alain Charmeau gave notice of his retirement.

Roussel is well-equipped to take on these challenges: He had been head of operations at Airbus Defense and Space since 2016, and while there—in 2014—he contributed to the creation of ArianeGroup, launch of the Ariane 6 and on-time progress of the program. But factors beyond his control will not make things easy.

ArianeGroup insists there is no relationship between the job cuts, lack of orders and Charmeau’s departure. The first decision stems from the program schedule, according to the company, as the transition between the Ariane 5 and Ariane 6 programs is scheduled to be completed by 2022 and fewer design engineers will be needed. ArianeGroup points out that 1,500 people have been hired since 2015 for the endeavor, and it wants to “strengthen its competitiveness.”
Planning ahead is the goal to avoid actual layoffs in four or five years. Some 1,300 jobs are expected to disappear due to retirements or termination of temporary contracts. The other 1,000 employees will be offered positions elsewhere within the Airbus and Safran groups. If they are on-site employees of a subcontractor, ArianeGroup will take their jobs in-house.

Maybe the most striking change in company plans is a reduced annual launch rate, to “8 or 9,” according to Philippe Gery, a CFE-CGC union representative who attended the works council’s meeting where the move was announced. The rate had been planned for 11 or 12.

The commercial geostationary market has been slow, and new constellation projects have yet to evolve into launches. The launch rate may be at the heart of the problem. For the in-service Ariane 5, it is around seven per year. Key to the anticipated 40-50% cost reduction is an economy of scale generated by the greater launch rate of the Ariane 6. The program has been entirely cost-driven, as opposed to aiming for improved performance, because of the competitive pressure from new entrants such as SpaceX. Less frequent launches thus may make ArianeGroup's position more difficult.

Charmeau’s retirement is linked only to his age (he turns 63 this year), an ArianeGroup spokesperson says, noting that “he had begun talking about [re-tiring] to the parent companies, Airbus and Safran.” For three months, he is acting as a special advisor to Roussel.

Meanwhile, a firm commitment from European institutional players for a minimum number of launch orders every year has proved elusive. The so-called European Institutional Ex- ploitation (EIE) agreement is expected to guarantee launch service operator Arianespace five Ariane 6 launches per year, in addition to three or four Vega Cs. (Italy’s Avio is Vega’s prime contractor.) Or, as Charmeau suggested a year ago, 34 Ariane 6s and 9 Vega Cs over four years, for an average of slightly fewer than 11 launches per year. In exchange, Arianespace would charge for launches at market prices, as opposed to the institutions subsidizing them.

“The joint statement on the institutional exploitation of Ariane 6 and Vega C.” They expressed “full support” for the European launcher industry and its programs. They “recognized the bene-fit” of aggregating their institutional demand but did not make their statement binding.

In an interview with French daily newspaper Le Figaro, Roussel said that to launch mass production, ArianeGroup needs 14 institutional orders.

Although it did order two, the EC may keep the company waiting for a broader commitment. Spending for 2021-27 is being discussed, a process that will probably end late this year or early in 2020, says an EC official, adding that “let’s consider it at a broader level, not program by program,” says Gery.

Another concern has been ArianeGroup’s productivity, as the goal set in 2014 has yet to be met, according to Gery. Since the creation of the company, “we have made progress in productivity, but that gain is insufficient, as we have been adding our work procedures one to another, rather than merging them,” he adds.

At least ArianeGroup’s defense business has been steady, thanks to French orders for submarine-launched ballistic missiles, the nuclear M51s, which account for more than one-third of its revenues.
Improved Engine Took Chang’e 4 Down to the Moon

> THE SPACECRAFT NEEDED A PRECISE DESCENT TO DODGE TERRAIN
> IT HAD TO WAIT FOR SUNLIGHT ON THE LANDING SITE

Bradley Perrett  Beijing and Sydney

Greater demands on engine performance have ranked high among the challenges for China’s Chang’e 4 lunar mission, as program managers looked for ways to achieve a descent to the rugged surface of the far side of the Moon. The landing on Jan. 3 demanded a nearly vertical approach, precise navigation and greater autonomy in engine operation, program officials say.

In launching Chang’e 4 on Dec. 8 and its communications relay satellite seven months earlier, the China Lunar Exploration Program achieved a schedule stated in mid-2017. It also performed the first soft landing on the side of the Moon that never faces Earth.

Chang’e 4 departed for the Moon on a Long March 3B rocket. Whereas the lander of the previous mission, Chang’e 3, made its descent 13 days after launch, the latest spent 26 days in space. This was necessary because the relative positions of the Earth and Moon required launch on Dec. 8 or 9, but the landing had to wait until the Moon’s 28-day rotation cycle brought enough sunlight to the touchdown site to power the lander and rover, state media say.

Progress in the China Lunar Exploration Program has been slow but generally successful. The effort has had three main objectives: sending a probe to orbit and map the Moon in detail, achieved with Chang’e 1 in 2007 and improved upon by Chang’e 2 in 2010; a soft landing and deployment of a rover, which Chang’e 3 performed on the near side in 2013; and bringing a sample back to Earth, the task of the next two missions, Chang’e 5 and 6. The even-numbered missions and their equipment are prepared essentially as backups for their immediate predecessors, the success of which makes the spares available for attempting something more challenging.

Misteps have included malfunction of the Chang’e 3 rover and an indefinite delay in the Chang’e 5 launch, due to failure of a Long March 5 rocket on an unrelated mission in July 2017. The lunar program was not responsible for the launch flop, however. The spacecraft of the two sample-return missions will be larger than their predecessors and therefore require launchers of the Long March 5 type, China’s largest.

Because of the rough surface of the far side of the Moon, Chang’e 4 had to make a precise landing and a nearly vertical descent: Approaching as Chang’e 3 did, along a shallow arc and with less precision, would have risked crashing into some topographical feature. Controllers initiated descent from an altitude of 15 km (50,000 ft.), at which time the craft was moving at 1.7 km/sec. (3,800 mph) relative to the Moon. A rapid attitude adjustment was made at 6-8 km altitude. At 100 m (330 ft.) altitude, the craft hovered to survey the terrain; it identified obstacles and chose a relatively flat spot, to which it slowly descended.

This process increased demands on the spacecraft’s main engine, which the Chinese industry described as a technical challenge even in its first version, used on Chang’e 3. For the latest spacecraft, the 7.5-kN (1,700-lb.-thrust) engine had to be more nimble in operation. In 2017, the institute that developed the engine said the one in Chang’e 4 would deliver thrust within 3% of the commanded value; the precision of output would be improved by calibrating its operation in space. Starting reliability had to be improved for the current mission, state media say. Thrust is said to be continuously variable from 20% of the maximum, though for Chang’e 3 the variable range was reported to be 1.5-5 kN, implying no graduation between those values and 7.5 kN was available.

Specific impulse, comparing thrust with propellant flow, was slightly improved in the new version to 310 sec. from 308 sec. Autonomy was enhanced so the unit could operate when unable immediately to receive commands from Earth. Guidance technology to support the landing had to be improved, too: Range and velocity sensors needed to achieve higher signal-to-noise ratios, because of the low microwave backscatter of the surface.

The Chang’e 5 and 6 spacecraft will each use two engines of the same type. Their launch dates have not been announced, however. Before the Long March 5 failure, caused by a manufacturing fault in a first-stage engine, Chang’e 5 was supposed to go to the Moon in 2017, ahead of Chang’e 4.

European countries have contributed scientific instruments to the current mission. Among the payloads on the lander are a landing camera, terrain camera and a low-frequency spectrometer. The rover has a panoramic camera, a penetrating radar and a spectrometer for imaging in visible and near-infrared frequencies. The relay satellite, necessary because a lander on the far side of Moon has no line of sight to the Earth, also has scientific functions.

The power source for the lander is a radioisotope thermoelectric generator. Such equipment releases energy from radioactive decay, usually of Plutonium-238. Apart from providing electricity, it is also generating heat to regulate temperature.

The pronunciation of “Chang’e” is quite unclear to non-Mandarin speakers; the “e” is pronounced as in “her.”
Rolls-Royce Sets Its Sights On Electric Airspeed Record

**> ROLLS-ROYCE-LED TEAM TAPS NXT AIRCRAFT AS BASIS FOR ACCEL**

**> ACCEL WILL USE 6,000-CELL LITHIUM-ION BATTERY PACK WITH A BESPOKE LIQUID-COOLING SYSTEM**

Accel will run on electric power with the aim of achieving at least 300 mph.

Tony Osborne London

A ero-engine manufacturer Rolls-Royce is hoping to make its mark on the electric aircraft speed record by breaking the 300-mph barrier in 2020.

Better known for its widebody engines, it is championing electric flight through developments such as the E-fan demonstrator, working with Airbus and Siemens on a hybrid-electric propulsion system on an Avro RJ100 regional airliner testbed. But the OEM also recognizes that the general aviation market could allow it to develop electric systems much more quickly than large-scale commercial or military programs.

To that end, it has embarked on Accel—short for Accelerating the Electrification of Flight—and is working with British electric-motor manufacturer YASA Ltd. and startup Electroflight to adapt an existing airframe, a Lycoming piston-engined Sharp Nemesis NXT kit-built racing aircraft, to battery power. Nemesis’ specifications claim the aircraft can cruise at 325 mph with its existing piston engine.

“Rather than growth into new platform areas, this is a recognition that electrification is a strong trend across the industry,” says Matheu Parr, Accel project manager. “This is really about how we use a different segment of the market to build that technology fast.”

Parr says Rolls-Royce carefully chose its challenges, focusing on battery, power train and the motor technologies to beat the current speed record of 210 mph (337.5 kph) set in 2017 by an electric-powered Extra 330 aerobatic aircraft modified by Siemens.

Work on Accel formally began in April 2018, and the 20-strong team has completed detailed design activity. They plan to move into building and testing the aircraft and its systems toward year-end, with flight testing planned for early 2020. Development is taking place at Electroflight’s facility at Gloucestershire Airport, England.

The team is hoping the electric propulsion will have the same mass as the NXT’s engine and fuel system, eliminating the need to recertify the aircraft with an adjusted takeoff weight. Parr says early tests on a subscale battery system are performing as expected. The team is continuing the tests by scaling up the battery system.

Ultimately, Accel is aiming to use a densely packed lithium-ion battery pack with 6,000 cells capable of delivering 750 kW of power.

The cells are similar to those in electric cars and power tools and designed to deliver high power-output levels, but the demands of flight also call for batteries that can provide endurance.

“To undertake a speed run, you need to fly four 3-km [1.9-mi.] runs over a set course, so you can’t go blisteringly fast once and then loiter for the next three; you have to sustain an average speed,” says Parr. “That pushes battery technology into a place where it doesn’t want to spend a lot of time.”

The ability to reduce temperature is one of the key innovations. A bespoke liquid-cooling system will keep the batteries at an optimum operating temperature of around 40C (104F) throughout the flight duration.

“We need high power but also high energy, and that is the challenge; that’s what aerospace is going to demand,” says Parr. The batteries will power a trio of YASA-developed lightweight motors, with the propeller shaft running through all three. “We think it’s the first time this approach has been done in aviation, one of the unique benefits of the motors we have,” he says.

However, plans to use a contrarotating propeller, detailed when the Accel project was first revealed at the Farnborough Airshow, were deemed a “step too far,” says Parr.

The battery and motors will be linked by an onboard power train that will operate at 750 volts, which the team believes will deliver 90% efficiency. Other developments in the project include an avionics system that will be able to monitor the battery condition and report on it to the pilot. An onboard monitoring system will collect 20,000 data points per second, measuring battery voltage, temperature and overall health of the power train.

Accel, along with other electric flight projects, has managed to secure British government funding. If successful, Rolls-Royce believes the technologies proved on Accel could be commercialized for training and electric vertical-takeoff-and-landing aircraft for urban air mobility.

The flights will also allow the team to better understand battery health and degradation. Parr notes that electric aircraft will probably need several battery changes throughout the 20-30-year life of a traditional aircraft.

The project will also take Rolls-Royce back to its roots. Besides breaking the 300-mph barrier, Parr and the team also have their sights set on the 343-mph speed achieved by the Rolls-Royce Type-R engine Supermarine S.6B seaplane, which won the Schneider Trophy in 1931 and ultimately led to the Spitfire fighter and the Merlin engine, arguably one of the most famous aircraft/engine combinations in history.

The team is likely to have competition, however: Several international teams have stated intentions to break the Siemens Extra 330 record, too.
New powers will allow police to require remote pilots to land their drones and produce proper documentation. They will also be able to seize a drone and collect electronic data from the device, ministers announced on Jan. 7.

Uncertainty still surrounds the events that forced closure of the UK’s second-busiest airport Dec. 19-21. Sussex Police investigating the incident said it had been caused by “numerous instances of illegal drone activity.” They are evaluating information from 115 witnesses who reported seeing drones operating in the vicinity of the airport. Two people arrested were subsequently released without being charged, and no further arrests have been made.

UK military anti-drone equipment was deployed to Gatwick during the incident in the form of both Leonardo’s Falcon Shield and also the Anti-UAV Defense System (AUDS) produced by Blighter Surveillance Systems, Chess Dynamics and Enterprise Control Systems. Gatwick’s operator has since purchased two sys-
COMMERCIAL AVIATION

tems, reportedly for £5 million ($6.4 million), while Heathrow’s owner has also ordered an AUDS.

Other airports are likely to follow suit. The UK Home Office is set to evaluate the safe use of a range of counterdrone technologies to prevent the aircraft flying over sensitive sites, including airports and prisons. Government ministers are expected to meet with airport bosses in the coming weeks to consider anti-drone strategies.

The rules governing the use of counterdrone systems are complex. Detection, tracking and identification can be performed legally, but jamming, hacking or otherwise defeating drones is widely illegal and can be performed only by government agencies, and then only with special legislative authority.

Jamming risks interfering with other nearby systems such as GPS, particularly at airports. Techniques for taking control of drones, such as protocol manipulation of the radio links, contravene anti-hacking laws. And techniques that bring down the drone, such as nets or projectiles, risk injuries on the ground.

AUDS is a military-grade counterdrone system, already in use with the U.S. Army. The full system includes radar detection, electro-optical tracking and identification and directional radio-frequency “inhibition.” Systems acquired by Gatwick and Heathrow are likely for detection/identification only.

During the Gatwick incident, police were reluctant to shoot down the drones for fear of where the bullets could land. Later, police marksmen were seen carrying shotguns as a potential mitigation.

There are many drone detection systems on the market, but their effectiveness is in doubt. In a July 2018 letter to U.S. airport operators, after evaluating several drone detection systems operationally at different locations, the FAA said interference from other airport radio systems made detection of drones difficult, if not impossible.

The FAA also suggested that a high level of manpower is needed to operate the equipment and discern drone activity. In the July letter, it also said countermeasure technology “could introduce greater hazards to the airspace than the unmanned air system-based hazard it is intended to mitigate.”

The central problem is that not enough is known about the damage a drone strike can cause to an aircraft, coupled with the wide range of drone types and sizes being flown—often at altitudes and over locations banned by existing regulations that are dif-

Air Transport Production Increases Could Slow, Analysts Say

SUPPLIERS REMAIN CAUTIOUS—WITH GOOD REASON

ALL-IMPORTANT NARROWBODY PROGRAMS SEEM TO BE FIRMING UP AGAIN

Michael Bruno Washington

The commercial aerospace manufacturing sector, led by Airbus and Boeing, continues to position for expected production rate ramp-ups of large commercial aircraft (LCA), say financial analysts looking into 2019.

But signals are flashing that further increases could be more gradual than in recent years, in part due to issues remaining from 2018. If so, the development might be welcomed by some nearby systems such as GPS, other airport radio systems and even Rolls-Royce had issues that a factor on some widebody aircraft, and even Rolls-Royce had issues that led to both delays in some [Boeing] 787 deliveries, as well as several disruptions of in-service aircraft.”

Also, there remain looming macroeconomic challenges according to Jef-feries analysts Sheila Kahyaoglu and Greg Konrad. “There is some belief that there are risks to the near-term outlook given some concern over a recession, which could alter delivery skylines. China remains an overhang, but we believe the risk is minimal. Challenges for emerging market carriers pose some risk to large orders that have been placed to meet lofty growth expectations,” they write.

Not surprisingly, all of this is leaving suppliers sobered. A December survey of the global aerospace and defense supply chain by Verify, a ma-jor A&D supplier performance management company, indicated almost
20% of the supply chain has little or no confidence in supporting narrowbody increases above those planned in 2019, while just under 30% are very confident (see chart).

"Only 17% in the Verify survey said the issue was supplier capacity, while 42% cited requirement flow down, and 24% cited schedule volatility," Herbert says, adding that is a positive sign. “However, even a small percent that is undercapitalized can create disruptions across the entire supply chain. Considering the issues in 2018, we believe the leading OEMs and their Tier 1 suppliers are spending more time and capital to do all possible to minimize this risk across the industry.”

It helps that narrowbody horizons at both Boeing and Airbus appear to be in good shape, the Jefferies analysts say, with the skyline solid through 2021. For total narrowbody aircraft in 2019, they believe a production rate of 120 aircraft per month is possible, which compares to a combined rate of 107 now. The rate increases are further enabled by more matured transitions to the next-generation types of the legacy single-aisles.

Whether that is enough to entice everyone else is a different matter. “Both OEMs have acknowledged upward bias to production rates, which appears to be well-supported when looking at forecasted deliveries,” write Kahyoglu and Konrad. “The bigger challenge could be convincing the supply chain, given needed investments to raise rates.”

Still, at least one major supplier appears to be giving a proverbial thumbs up. Spirit AeroSystems says a final, new “master” agreement with very important customer Boeing should be wrapped up by Jan. 31. The leading aeronautics provider and Boeing in late December agreed on the outline of their deal over pricing for a swath of aircraft “well into the next decade,” according to Spirit, as well as a release of liability and claims asserted by both companies related to 737 disruptions in 2018.

Herbert says the deal underpins significantly higher 737 production levels. “Barring a major demand disruption, or risk that the supply chain is not able to support a rate higher than 57/month, we believe Boeing will look to monetize its 737 backlog sooner rather than later, which to us implies [a rate of] 60/month to 65/month could now be a higher probability,” he says. ☀
Airbus Says Skywise Digital Platform Will Cut Development Cycle

DIGITAL CONTINUITY EXPECTED TO IMPROVE QUALITY IN PRODUCTION

ITHEN-LIKE APP MARKET TO APPEAR NEXT YEAR

Thierry Dubois Paris

A irbus executives promoting digitalization and running up against resistance have an answer to the naysayers: the Skywise data-sharing and analysis platform.

The system offers tangible evidence of the value of creating a digital continuum along the design and production process, not to mention with airlines and suppliers. And the Skywise endeavor is only the beginning of a wide-ranging change. Airbus expects a major improvement in the aircraft development cycle, while customers can expect strides in reliability.

Suppliers began joining Skywise late in 2017. In a matter of months, one, Liebherr Aerospace, better understood the behavior of its engine bleed valves. Skywise gave it access to data—including weather—it analyzed and correlated to in-service failures or early removals. For instance, engineers found a thunderstorm can cause accelerated aging of a part. Armed with this information, it could devise new, customized maintenance recommendations.

“Three or four years ago, we understood there was a solution,” he says. Thanks to the Skywise partnership with Palantir Technologies, Airbus can focus on content. The breakthrough is seen in unlimited storage and the ability to process heterogeneous data. Whether the system is connected to a factory, an aircraft or an airline operation, “you get clean, traceable and comparable data,” says Fontaine.

For the airframer’s next clean-sheet design, he expects a 30% shorter development cycle and an equivalent reduction in development cost. “We could have a five-year cycle,” he says. Quality would be better right from the first production aircraft, and the ramp-up would be swifter, he says.

Airframers expect software for digital design, manufacturing and services to evolve. “[Information technology] systems in production do not work in the same frame of reference [as computer-aided design software]; you have to extract data,” says Fontaine. Going forward, design software will have to provide for digital continuity.

Early in the A380 program, a wiring problem plagued the cabin production process. The root cause could be found in poor interfacing between design and production. “Given those problems, we decided to extend the use of the design office’s digital mockup to A350 production. We did it for wiring and cabin installation—two areas deemed critical,” says Fontaine. A digital mockup has yet to be implemented for the A350’s entire final assembly process, however.

After large suppliers like Liebherr and Premium Aerotec, small and medium enterprises (SME) may join Skywise. “A Tier 4 supplier may thwart our production line, but it cannot afford what we can—Skywise is the answer,” says Fontaine, noting that the platform’s core, which enables data integration, is free. Only a couple of SMEs, however, are considering joining.

An airline or other Skywise user contributes by sharing data—to a chosen extent. It can also contribute by creating an app it will make available to others. Such an iTunes-like market is planned to appear in Skywise in 2019.

Another trend is the enrollment of non-Airbus aircraft. For an airline, being able to use Skywise for only a part of its fleet would be a nonstarter, Fontaine notes. Neither Skywise nor Boeing’s terms and conditions prohibit it using the digital platform to collect, share and analyze operational data. Skywise’s data-governance scheme guarantees Airbus engineers cannot see Boeing or Embraer data.

Digital Transformation Officer Marc Fontaine. Forty apps have been developed for company use, “from quality problem-solving to flight-test preparation and traceability,” he notes. Skywise has 6,000 Airbus users, 40% of which use the platform for self-service, he says, adding: “A user can create his or her own application.”

Skywise is useful in maintenance, helping pinpoint reliability issues. One persistent issue with the A380 fuel pumps took only two weeks to solve. Before Skywise, engineers had spent over two years trying to find the root cause with only limited access to data. “Delivering data at the right time, to the right person, works,” says Fontaine.

Integrating data from various sources is key. “It is 75% of the value,” says Fontaine. Sharing data between two different teams at two different factories used to involve lengthy, costly upgrades in enterprise resource planning software.

“Three or four years ago, we understood there was a solution,” he says. Thanks to the Skywise partnership with Palantir Technologies, Airbus can focus on content. The breakthrough is seen in unlimited storage and the ability to process heterogeneous data.
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Within a few days of each other in early January, two companies announced major changes to their businesses—but they were polar opposites.

Monarch Aircraft Engineering declared bankruptcy and is selling off parts of its business, which obviously negatively affects employees, customers and suppliers. In its rollercoaster ride of a little more than a year since its parent company, Monarch Airlines, abruptly went out of business, the MRO looked like it would succeed as a stand-alone entity, so its Jan. 4 filing was a surprise (see MRO22).

On the flip side, while not a surprise, Pratt & Whitney’s Eagle Services Asia has been working hard for more than a year—and has spent $85 million—to modify its Singapore facility for the PW1000 geared turbofan, of which nearly 10,000 have been ordered. On Jan. 8, it announced receipt of European Aviation Safety Agency and Singapore certification for the geared turbofan and induction of the first PW1100G-JM.

To prepare for maintaining the geared turbofan family, Eagle Services Asia, a 20-year-old joint venture between Pratt & Whitney and SIA Engineering Co., separated the PW4000 and GTF operations into unique spaces and started afresh for the new engine—from a new engine flow line instead of an engine bay concept, ways to prevent employees from lifting heavy objects and new machinery to handle grinding, stacking and balancing. It also incorporates Connected Factory concepts—including paperless work instructions and sign-offs, tooling and a very tall carousel storage and retrieval system for tool and parts management.

The facility, which is Pratt & Whitney’s global center of excellence for PW4000 engine overhauls, also needed to modify its test cell. Although the PW1100G-JM has a lower thrust rating than the PW4000, the geared turbofan “has the highest bypass ratio of any engine in the industry,” says Joe Sylvestro, Pratt & Whitney’s vice president for aftermarket operations, so “to take in and put out more air flow, one test cell was retrofitted with a new and larger inlet tube and exhaust stack.” The test cell’s software and soundproofing system also were upgraded.

Enhancing operational efficiency and productivity is important as the GTF ramps up, with more than 300 engines in the Asia-Pacific region expected to need support and retrofits in 2019, compared to about 200 in 2018.

But inserting new technology into a facility alone is not enough. Pratt is upskilling its workforce to harness the new tech, says Sylvestro. Maintainers receive 16 weeks of hands-on and classroom training on the PW1100G.

Expect 2019 to be full of changes, as the fleet transitions, disruptive innovations emerge and upsets occur.

—Lee Ann Shay

Keep up with Shay at MRO-Network.com and on Twitter @AvWeekLeeAnn
Feb. 10-12 — MRO Middle East Summit and Expo. Dubai.
March 4-6 — SpeedNews 33rd Annual Commercial Aviation Industry Suppliers Conference (ASC). Beverly Hills, California.
March 6-7 — MRO Southeast Asia. Kuala Lumpur.
March 26 — ATW’s Airline Industry Achievement Awards. New York.
April 8-10 — Routes Europe 2019. Hannover, Germany.
April 9-10 — Military Aviation Logistics and Maintenance Symposium. Atlanta.
April 9-11 — MRO Americas. Atlanta.
Highlights

MRO Japan Starts Business at Naha

MRO Japan started operations at Okinawa’s Naha Airport in early January, with a grand opening planned for late this month, says Tadaaki Nobusue, head of sales and marketing for the young Japanese maintenance company.

The government of the Okinawa prefecture constructed a hangar with three narrowbody bays and one widebody bay at Naha at the end of October. MRO Japan has been moving staff and equipment from Osaka to Naha since then.

“We focus on narrowbody aircraft maintenance with painting,” Nobusue says. Since starting up in 2015, MRO Japan in Osaka has performed more than 300 base maintenance events for Airbus A320-family aircraft, Boeing 737s and Bombardier Q400s.

Heavy check customers include parent All Nippon Airways, Vanilla Air, Peach Aviation, Star Flyer and Solaseed.

The company plans to add the Boeing 787 and Mitsubishi Regional Jet to its capabilities, becoming the MRJ’s preferred provider in Asia.

Latin American 2019 Forecast

Expect the Latin American market, including Mexico, to generate $4.1 billion in MRO demand in 2019. Engine maintenance will generate 34% of that demand, followed by components (23%) and line maintenance (20%). MRO for the Brazilian civil aviation market is expected to be worth $971.4 million, and Mexico’s MRO market is estimated at $793.2 million in 2019.

Building an Independent Full-Service MRO in Australia

Heston Aviation acquired Aircraft Maintenance Services Australia, a line-maintenance company, because it sees an opportunity to develop a truly independent one-stop MRO provider in Australia, says Heston Partner Jonas Butautis.

Heston began a few years ago as an aircraft leasing and trading company but recently expanded its management team with individuals experienced in developing independent MRO companies by blending capital and engineering strategies. “It was a natural strategic direction to look for global MRO opportunities that we can buy and add value to through accumulated knowhow and capital,” Butautis says. “Aircraft Maintenance Services Australia, or AMSA, was a perfect fit for this purpose.”

Butautis notes there is a group of global MRO companies that blend labor-intensive MRO with capital-intensive asset management, including AAR, GA Telesis and ST Aerospace. He says that Heston believes in this business model: “MRO engineering infrastructure adds value to asset operations and vice versa, asset projects help develop independent MRO service offerings.”

Heston is not looking at AMSA just for its line operations. “We see AMSA as a platform to develop a full-scale, multiservice independent MRO company in Australia and the wider region,” Butautis says. AMSA will be rebranded and will add component, engine and engineering solutions and possibly move into limited heavy maintenance as well. “There is an empty space for independent heavy maintenance in Australia; we see this as an opportunity.”

Contracts

AAR won a $51 million U.S. Marshals Service contract to provide maintenance/logistics support for its Boeing 737s owned and operated by the Justice Prisoner and Alien Transportation System in Oklahoma City. The deal includes supporting another 737 at Las Vegas.

American Airlines inducted its first CFM56-5B into its Tech Ops-Tulsa facility for maintenance. Work was previously performed by GE Aviation prior to contract expiration in October 2018.

ATR secured a global maintenance agreement from Bahamasair for three ATR 42-600s and two ATR 72-600s.

IAE International Aero Engines won a 10-year contract from Chile’s JetSMART to perform V2500 maintenance.

Joramco extended its Boeing 737 heavy maintenance deal with Flydubai. The contract calls for 45 C checks, entry-into-service checks and cabin mods.

Lufthansa Technik won a Total Component Support contract from Eastar Jet of South Korea for six 737 MAXs.

Magnetic MRO of Estonia secured a three-year Enter Air contract to provide power-by-the-hour component support for 19 737-800s.

Pratt & Whitney won a 12-year Philippine Airlines contract to provide EngineWise services, which includes engine fleet data analytics and real-time intelligence to predict and prevent engine disruptions for 15 GTF-powered Airbus A321neos.

Rolls-Royce secured Jackson Square Aviation and CDB Aviation as launch customers for its new LifeKey component to its LessorCare service. It has signed LessorCare contracts with 11 customers.
Stepping Up

Each December, the Aviation Technician Education Council (ATEC) publishes The Pipeline Report—a compilation of data derived from aviation maintenance technician school (AMTS) survey responses, FAA databases and National Center for Education statistics. Previous ATEC reports highlighted the leaky pipeline of would-be mechanics who fail to attain certification or forgo careers in aviation altogether. The 2018 report suggests the tide is turning, in direct correlation with enhanced aviation community involvement in technician education. Combating top deterrents should be the focus of industry-education partnerships looking to capitalize on the momentum.

According to the FAA’s airman certification branch, 63% of new mechanics come from Part 147 maintenance schools. The remainder achieve certification on the basis of previous civilian (27%) or military (10%) experience. The report says that the current AMTS framework has the potential to double the number of mechanics it produces (4,033 in 2017) if more attention is paid to (1) encouraging exiting students to take the FAA mechanic test, (2) better marketing and defining career opportunities in aviation, (3) ensuring schools have relevant equipment and materials to support aviation training programs and (4) hiring and maintaining adequate numbers of qualified AMTS instructors.

The data suggest that an uptick in aviation community involvement—40% of survey respondents cited industry partnerships as a reason for anticipated enrollment increases—has helped make progress toward the first two objectives. In 2017, the number of students choosing non-aviation jobs over their aviation counterpart dropped by nearly half over the previous year. And 70% of AMTS students are taking the FAA mechanic exam upon graduation, a 10-point increase over the previous two years.

Another contributing factor: The average starting hourly rate for AMTS alumni is increasing, reported as $19.70 per hour, up by 40 cents from the previous year.

While industry is seemingly doing a better job of retaining individuals already in the pipeline, ATEC suggests more can be done to draw in future mechanics. While schools anticipate a very aggressive 40% increase in aviation program enrollments next year, similar projections in years past proved overly optimistic. During the last five years, AMTS enrollment has stayed relatively stagnant, increasing by only 1.7%. And the number of individuals obtaining mechanic certification by virtue of AMTS program completion is far lower now than it was 15 years ago.

Schools will need to increase enrollment soon to meet growing demand. Currently, new entrants make up 2% of the population annually, while 30%

Wake-Up Call

Australia’s Civil Aviation Safety Authority (CASA) is taking a look at its fatigue management rules at the behest of community stakeholders. While the proposal is limited in scope to operations personnel, expansion to include other sectors, including maintenance, is expected.

Proposed Civil Aviation Order (CAO) 48.1 Instrument 2019 was published in response to formal recommendations made after an independent review. The new rule is applicable to air operators, flight-training organizations and some flight-crew license holders, and it will replace the current prescriptive rule with an outcomes-based approach. It also will consolidate all fatigue rules into a single instrument, creating a central location for current and future rulemakings on the subject.

While the proposal does not address maintenance personnel, CASA says it intends to distribute surveys to collect information in support of regulatory development that would make fatigue rules applicable to maintenance, cabin crew and air traffic control personnel. CAO 48.1 is expected to be released in February. High-capacity regular transport operators will be required to comply with the new rules by September. All other operators must comply by March 2020. Comments on the proposed operational fatigue rules are due Feb. 10.

—Crystal Maguire
There is significant opportunity for MRO industry employers to help define career paths and attract more individuals into the pipeline.

(as has been the case over the last decade), schools will need to increase enrollment by 30% starting this year to make up the deficit.

Compounding the challenge: A school’s ability to increase enrollment is largely dependent on growing its own staff. Nearly 90% of survey respondents said hiring and retaining qualified instructors posed some risk to their aviation programs, a very real limitation to program expansion.

The report also provides intelligence for companies looking to make partnerships more impactful. Respondents report that the best way to recruit a new graduate is to offer that person employment while in school. Tuition reimbursement programs and internship opportunities were also high on the list. And moreconcerted focus on supplying relevant training equipment and materials would address what was cited as the second-largest threat to technical schools (right behind hiring and retaining qualified instructors).

As a whole, the report reiterates the common assertion that industry-education partnerships clearly defining of the workforce is at or near retirement age. At that rate, the mechanic population is expected to decrease 5% in the next 15 years. Forecasts by the U.S. government and Boeing also project a need for thousands of additional mechanics in the next 10-20 years. Assuming the number of new mechanics obtaining certification on the basis of military or civilian experience continues its downward trend. More concerted effort is needed to make up the deficit.

While growth and demand are expected to slow, the association also anticipates that lower fuel prices will spur a run of profitable years. Coupled with an expected 5% growth in passengers and increased load factors, airlines are projected to net an average of $7.75 per flying passenger in 2019 (or $16.77 per passenger for North American air carriers).

The average estimated pre-tax airfare for this year is $324, 61% cheaper than the same ticket purchased 20 years ago.

“Air travel has never been such a good deal for consumers,” says IATA Director General and Chief Executive Officer Alexandre de Juniac, who revealed the projections at the association’s Global Media Day in December. “Not only are fares staying low, the options for travelers are expanding.”

IATA says 1,300 new direct links between cities were opened last year, growing the number of unique city-pairs served to more than double what they were two decades ago. 

—Crystal Maguire
ENACTING A NEW SIX-YEAR FAA BILL in late 2018 was a major achievement, both for Congress and the many industry organizations that helped shape the legislation. ARSA is particularly proud of its leadership role in creating a new federal grant program to recruit and train maintenance technicians.

With the FAA bill complete, the aviation policy focus is shifting from Capitol Hill back to the executive branch, which must implement the new law. Officials at the FAA as well as in the Transportation and Homeland Security departments, the Transportation Security Administration, Government Accountability Office (GAO) and other agencies have their work cut out for them. The 462-page bill (which reauthorized not only the FAA but also the TSA and which affects other agencies) is full of congressional directives to enact new regulations, set up new advisory bodies, undertake studies, complete reports and establish new programs.

Congress mandates government action by directing the administrator or secretary of the relevant agency or department using the phrase “the administrator [or secretary] shall.” If you search the phrase “administrator shall” in the FAA bill, you’ll find that it appears 478 times; “secretary shall” appears 126 times.

Those numbers should be a wake-up call about the massive impact that executive branch policymakers will have on the aviation industry in the years ahead. In response, businesses and their association representatives must step up engagement, not just to prevent bad things (e.g., poorly thought-out regulations) but also to improve the way the government works.

ARSA has carefully reviewed the bill and compiled a matrix of more than 40 provisions that may potentially impact the maintenance industry. The association will petition to join stakeholder bodies, contribute suggestions about ways to improve FAA operations and training programs, provide information to support various GAO studies, work to ensure that the technician-training grant program is a top priority and coordinate with our members and industry allies to ensure our efforts are aligned.

The work of passing the FAA bill is complete, but the challenge of implementing it in a way that best serves the needs of the aviation community while upholding safety has just begun. Here’s how you can get involved:

(1) Review the ARSA matrix (visit arsa.org/faa-reauthorization-2018) and (if you have time), the bill itself.
(2) Consider the association’s priority levels for each initiative and compare them to what you believe are the most pressing areas of need for your business.
(3) If you work with trade association or corporate government affairs offices, contact them regarding your priorities and help find ways to shape the work of the FAA and other agencies (individually and through industry groups).
(4) Find opportunities in 2019—the sooner the better—to come to Washington and engage both on and off the Hill. (ARSA’s annual conference in March, which has days of both executive branch and legislative engagement, is a good example.)

Now is the time to understand what is in the new law and how your company will be affected. More important, this is your chance to become active at every point where “the administrator shall” do something that affects your work.

Christian A. Klein is the managing member of Obadal, Filler, MacLeod & Klein, plc, overseeing the firm’s policy advocacy practice. He represents trade associations as a registered federal lobbyist and provides strategic communications and legal counsel services to clients. He is executive vice president of the Aeronautical Repair Station Association.
Miguel Montoya, senior vice president of engineering and maintenance at Avianca, has led several large projects for the airline group, including launch of the Rionegro City, Colombia, MRO and adoption of the AMOS integrated software package. He also was responsible for standardizing technical processes and digitalizing systems at Avianca Holdings.

Avianca Holdings is reportedly planning to launch a regional carrier in Colombia early this year. Is this still in the works, and if so, what is the status of it?

In 2019, Avianca will begin operating a regional subsidiary airline to serve routes to medium and small cities in Colombia. Through this airline, Avianca aims to improve connectivity and drive aeronautical development in Colombia. This new airline will offer new destinations and new direct flights from different cities within Colombia, not just from the capital.

We expect the fleet to have 12-15 ATR 72 and ATR 42 aircraft, which can operate at smaller airports. The operation aims to be more flexible and efficient. The airline is on its way to gaining regulatory approval to operate in 2019.

How is the business agreement between Avianca, Copa Airlines and United Airlines going to work?

On Nov. 30, Avianca Holdings’ airlines (Avianca) announced that it has reached an agreement with United Airlines and Copa Airlines to realize a strategic and commercial partnership that will bring new service and innovation for passengers traveling between the U.S. and 19 countries in Latin America. Avianca expects this agreement to bring benefits to travelers, communities and the marketplace. The companies—all members of Star Alliance—reached the agreement following a global trend toward similar cooperative arrangements in the airline industry.

By integrating their complementary networks in this strategic and commercial partnership, Avianca, United and Copa expect the agreement to cover the U.S. and many Latin American countries, including Argentina, Belize, Bolivia, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guyana, French Guyana, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay and Venezuela.

It is important to highlight that the main benefits of this alliance are for air travelers, including joint service between the companies so that customers will have more than 12,000 connection options, new nonstop routes, additional flights on existing routes, and reduced travel times.

It has been eight years since Avianca and TACA merged. Does Avianca still send any maintenance to Aeroman, which used to be part of TACA?

The contract between TACA and Aeroman to complete services ended in December 2016, where there were two production lines contracted to support TACA. Since the launch of the Avianca MRO in Rionegro (near Medellin, Colombia) in 2017, all the maintenance services of the holding are being carried out at this MRO of Avianca, one of the most modern maintenance centers in Latin America, with capacity to service more than 100 aircraft per year.

Has Avianca’s recently launched new service to Munich increased your company’s work with Lufthansa Technik? How will this new service affect Avianca’s MRO operations?

Avianca signed an agreement with Lufthansa on Nov. 15, 2018, which covers line maintenance services at Munich station. Avianca has no technical personnel at this base so we decided to have a third party perform line maintenance, in this case, Lufthansa.

Avianca has multiple contracts for maintenance services with many MRO providers where Avianca has no personnel on site or has no capability to perform them. Such service providers fulfill all Avianca maintenance manual requirements and regulatory standards.

Avianca Cargo recently began operating direct cargo flights to Brussels. Which company is handling MRO for Avianca in that location?

Avianca Cargo is currently in negotiations with Lufthansa Technik Brussels to define the terms and scope of the maintenance services required for the Airbus A330 cargo fleet that is operating in Europe.

Avianca had to ground some of its Boeing 787 aircraft due to Trent 1000
Engine repairs. How have the repairs progressed, and when are regular operations expected to start again?

Avianca is operating all of its aircraft thanks to the planning and repetitive inspections that have given us a prudent reaction time responding to aircraft-on-ground situations in very short time frames. In 2019, due to the issue of repairs for the Trent 1000, we hope to have one aircraft at a time on the ground (for repairs) throughout the year. Rolls-Royce said that the definitive answers to the problems of the engines will begin to be implemented in early 2019, so it is expected that by 2020 the operation of the 787 fleet will be fully normalized.

Avianca is equipping its aircraft with Wi-Fi. What is the progress on that project?

Last Nov. 26, Avianca began a free trial of Inmarsat’s GX Aviation inflight broadband service on selected aircraft. At the moment, the services are offered on two Airbus A320s: N284AV and N562AV. The introduction of inflight broadband on our first aircraft is a milestone in Avianca’s digital transformation and supports our mission to provide a world-class onboard experience for passengers. During this trial period, we will continue to monitor and fine-tune the service performance prior to entering commercial service next year.

The initiative marks the Latin American debut of GX Aviation, Avianca’s Wi-Fi supplier and the world’s first and only global, high-speed inflight broadband service, delivered through a wholly owned and operated network of Global Xpress high-throughput satellites.

Under Avianca’s extended global maintenance agreement with ATR from last year, Aircraft Propeller Service was set to provide propeller training to Avianca’s technicians. What was involved with that training, and are Avianca’s technicians handling propeller repairs in-house now?

This training is related to line maintenance operations and basic inspections to be performed during transit and overnight checks. Avianca has no plans to increase its propeller repair rating in the coming years.

Are there other plans to bring more work in-house?

Avianca is always looking to increase its capabilities for in-house work if the business case analysis supports it. In 2018, we included several new repair items, highlighting these in particular:

- Boeing 787 airframe heavy check rating: three airframe heavy checks already performed in 2018 and four scheduled for 2019
- Emergency slide/life raft repair for the 787
- Panasonic IFEX1 and IFEX2 7-, 9- and 10-in. screen repair
- CFM56 engine mount inspection and repair
- Oven control panel repairs for Boeing 787, Airbus A320 and A330
- Flight crew seat overhaul and emergency slide maintenance for the 787 fleet
- Flight crew and portable oxygen bottle overhaul
- Powered drive unit repairs for the A330 cargo fleet
- Retractable landing light on the A320 and cooling fan repairs for the A320 and A330 fleets
- Increasing our calibration capabilities in Salvador and including vibration calibration capability.

Avianca began using AMOS MRO software in 2016. Has the company implemented any other software or technological solutions since then?

Avianca replaced the SIO operations system, through NetLine, to standardize the holding company’s operating system and integrate it with AMOS for control of flight hours and cycles. Additionally, the use of iPads for maintenance technicians was implemented, so they can access AMOS Mobile, maintenance manuals and social networks with the use of Windows 365. Also, there was implementation of the electronic flight bag with the use of iPads in the cockpit for pilots and co-pilots.
Last Nov. 26, Avianca began a free trial service on selected aircraft. At the moment, the services are offered on two bands on our first aircraft is a milestone for Avianca’s digital transformation in early 2019, so it is expected that by the year. Rolls-Royce said that the де-.engineering maintenance operations and basic inspections to be performed during transit conditions in Salvador and including vibration testing. For 2019, we will include Boeing 787, Airbus A320 and A330 maintenance agreement with ATR Panasonic IFEX1 and IFEX2 standardization calibration capability. Retractable landing light on the A320 and A330 feet. Powered drive unit repairs for the 787 feet. Flight crew and portable oxygen bottle overhaul. Oven control panel repairs for the A330 cargo feet. CFM56 engine mount inspection. Flight crew seat overhaul. Service was set to provide propeller service, delivered through a wholly owned and operated network of Global Xpress high-throughput satellites. Fi supplier and the world’s first and only global, high-speed inflight broadband network across the region by connecting with 4800+ attendees.

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Electric Propulsion Primer

As electric propulsion evolves, can engine MROs adapt?

Paul Seidenman and David J. Spanovich San Francisco

While it may be as much as a decade or more away, some type of commercial aircraft powered by electric propulsion may become as common as electric automobiles are today.

Should that happen, as industry experts predict, it would profoundly change the engine MRO industry’s traditional business model, after generations of maintaining fossil-fuel-powered reciprocating and turbine designs. To appreciate that, it is helpful to understand where electric propulsion development is today and where it is likely to go.

According to a survey published by Roland Berger, a global aviation consultancy, as of October 2018, there were 134 aviation-related electric propulsion projects in progress, primarily in North America and Europe. Of those projects, 70% were focused on pure electric engines, using motors that draw power from batteries recharged at ground-based charging stations.

In fact, all-electric propulsion is already in use, with one example being the Pipistrel Alpha Electro, a two-seat, single-engine trainer built by Pipistrel Vertical Solutions in Slovenia. The model is certified as a light sport aircraft (LSA) in France, Norway, Switzerland and Australia. In the U.S., it holds an FAA special airworthiness certificate, but Pipistrel is working with the FAA to certify it as an LSA so that it can be used as a for-hire trainer. To do so would mean changing current regulations, however, which require reciprocating power for certification.

The other 30% of the projects in the Roland Berger survey focus on hybrid-electric technology, which uses a combination of battery, generator and turbine engine powered by jet fuel.

Within the hybrid-electric group, there are two basic types. One, referred to as a “parallel” hybrid, incorporates a mechanical connection between engine and propeller, allowing the operator to run the engine drawing power either from the battery exclusively or via the turbine engine, says Nikhil Sachdeva, a senior consultant in Roland Berger’s London office. The operator may switch between them as needed. The other, known as the “series” hybrid, has no mechanical connection between engine and propeller, with the turbine charging the battery, which provides the energy for propulsion. Research is being done to identify the most efficient hybrid architectures, potentially incorporating the features of both parallel and series types, he says.

“Conventional engine architecture is extremely complex and expensive,” Sachdeva points out. “If the purpose of the turbine in the future will be limited to generating electricity, the engine will be less complex, smaller and less expensive, and less likely to have to deal with off-design factors such...
As exposure to temperature extremes, lightning or bird strikes,” he says. “This means that the MRO aftermarket will logically decline.”

Sachdeva reports that, based on Roland Berger’s surveys of aerospace industry executives, the first hybrid-electric airliner will likely enter service by about 2032, specifically as a 50-seat, revenue-generating aircraft that would typically fly stage lengths in the 340-km (211-mi.) range. “That is roughly the distance between London and Paris,” he notes.

Unlike hybrid-electric propulsion technology, which favors larger aircraft, all-electric engines will most likely be applied to smaller aircraft in the 2-4-seat category such as urban air taxis and trainers, Sachdeva notes. “However, we could see some application to the sub-regional segment—aircraft with 19 seats or less,” he says.

**ELECTRIC AFTERMARKET**

Given that electric propulsion technology is still largely in its infancy, the extent to which it will upend or disrupt the engine aftermarket service sector is largely unknown. “It is almost impossible to provide a clear answer to this question today, especially if we look at the complete aircraft and not only the propulsion system,” says Rolf Henke, a professor and member of the Board for Aeronautics and Technology of the German Aerospace Center, commonly known as the DLR, in Cologne.

An electric motor, he explains, will probably require “less service effort” than a gas turbine or piston engine in terms of numbers of parts and materials. “The propulsion itself will not change too much since thrust will come from a fan, which does not care whether it is driven by an electric motor or a gas turbine,” Henke explains, adding that while batteries and cables may need slightly fewer repairs than the tanks and pipes on conventional fuel-burning engines, they may need to be exchanged more often.

Henke also stresses that the final design of an electric or hybrid-electric propulsion system certified for transporting passengers over a long distance does not exist today; nor is it known what skillsets or qualifications will be needed to service the engines.

“Taking an MRO company’s view, a hybrid system will be more complicated and, therefore, need more qualification plus increased maintenance effort,” he says. “However, our current MRO companies are somewhat prepared, since one
The transition to electric propulsion is driving change in the MRO sector, as the focus shifts from traditional maintenance to software-enabled repairs.

**Electric Aircraft Development**

<table>
<thead>
<tr>
<th>Propulsion Type</th>
<th>Aviation Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Propulsion</td>
<td>Urban air taxi (eVTOL)</td>
<td>30%</td>
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<tr>
<td></td>
<td>General aviation</td>
<td>13%</td>
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<tr>
<td></td>
<td>Regional aviation</td>
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<tr>
<td></td>
<td>Large commercial aircraft</td>
<td>2%</td>
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<tr>
<td>All-Electric Propulsion</td>
<td>Urban air taxi (eVTOL)</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>General aviation</td>
<td>32%</td>
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<tr>
<td></td>
<td>Regional aviation</td>
<td>34%</td>
</tr>
<tr>
<td></td>
<td>Large commercial aircraft</td>
<td>4%</td>
</tr>
</tbody>
</table>

*Includes more than 130 publicly known electrically propelled aircraft programs as of October 2018

**Mainly turbo-electric

Source: Roland Berger

Amanda King, senior director of breakthrough technology at Honeywell Aerospace, reports that the changes will mostly involve digital solutions, according to Amanda King, senior director of breakthrough technology at Honeywell Aerospace. The OEM, reports King, is engaged in research and development to support a suite of electric propulsion solutions for aircraft ranging in size from a small urban air taxi to a larger fixed-wing regional airliner.

“More software will be imbedded in these engines, which means that for MROs there will be more software-enabled repairs, such as updates,” King says.

In that regard, King explains, with better-connected systems, the MRO models will be more service-based, rather than event-spaced.

“I predict that maintenance in the electric- and hybrid-propulsion aircraft will be based on connected software with health monitoring, which will likely be a ‘service’ for an operator. When the state of health is indicated as at or below a certain threshold, the health-monitoring service will tell the operator to get maintenance. That is different than how most parts work today, where maintenance is based on a time-schedule of either flight hours, months, etc., and the maintenance is performed whether it is required or not,” says King.

She points out that this should save operators time and money “by preventing failures that may otherwise occur between regular maintenance checks in the traditional model. For the evolving [vertical-takeoff-and-landing] market, up time will be increasingly critical to the success of these operators.”

For MROs, a whole new approach to training will be required to service electric propulsion systems, King stresses. “As they evolve, a training system will have to be developed in parallel,” she says. “To do that, the OEMs will have to have an extensive amount of input from the MROs at the design phase to minimize repair complexity. Unfortunately, we haven’t seen much involvement of the MROs at the electric engine development stage. That is something that will have to change.”

King also raises another interesting point that could be a disruptive influence on engine MROs. “Today’s aircraft are powered by engines that will be in service 20-30 years. But with the emerging electrically powered air taxi model, there will be more expendability and greater rates of replacement—without compromising safety—as new versions of the engines come about—much as people replace smartphones or other electronics today,” she says. “I think this is something the MROs will need to take into account.”

**AN EPIC SHIFT IS COMING**

Fergal Whelan-Porter, CEO of Aeolus Engine Services, a Dublin-based specialist in turbine engine light maintenance, condition monitoring and troubleshooting, predicts that electric propulsion will “drive an epic shift” in the way engine MRO providers do business. “It will be a destructive force with respect to the traditional aircraft engine service model, since it will involve new technologies, new materials and new facilities,” he says.

On the positive side, Whelan-Porter points out that the capital investment required to establish facilities that service electric-propulsion engines should be considerably less than for conventional engines. To illustrate, he says, servicing electric-propulsion engines will be less labor-intensive and will not require heavy equipment, such as the space-consuming, immovable grinding machines needed to repair today’s turbine engines. In addition, electric engines will employ fewer components so fewer spare parts will be needed, and repair procedures will differ.

“It will be a lot more cost-effective to set up the facilities to service electric engines, based on these factors,” Whelan-Porter says.

He also agrees that servicing electric propulsion systems will be more dependent on software solutions, which means more maintenance will be done by the operator and less by MRO facilities. “There will be a transition from today’s heavy maintenance to more line service, since data can be downloaded anywhere,” Whelan-Porter predicts. “There will also be fewer manual labor procedures that need to be carried out, and consequently, new skills will be needed for the new technologies. Effectively, one MRO market will be replaced by another.”
In Ganzarski’s view, electric propulsion will create a hugely disruptive impact on the aftermarket engine services industry. One example he cites goes to the heart of today’s engine OEM customer support.

“Turbine- or piston-engine OEMs will normally sell their engines for very low prices, with the intention of making up their costs through their maintenance plans. But, for an electric engine, that model will disappear, because with significantly fewer moving parts—which account for the majority of maintenance—the whole notion of A, B or C checks goes away.”

In preparation for the first flight of a pure electric-powered Cessna Caravan in 2019, MagniX is testing motor and system integration on its iron bird testbed in Australia, using a 350-hp electric motor.

“Additional support hardware and software tooling will be needed for the new propulsion system, and this will be developed in support of the safety case as the project progresses,” says Paul Hutton, CEO of Cranfield Aerospace Solutions, with reference to a project to apply electric-propulsion retrofits to the piston and turbine versions of the Britten-Norman Islander at the demonstration level by 2021. The high voltages involved in the new propulsion system will require skills development for the MRO organization to ensure worker safety. “As well as airlines, we are in discussion with an airports operator to ensure that the support infrastructure for both operation and maintenance is identified and planned for upon entry into commercial service in 2023,” says Hutton.

Also anticipating major changes in the MRO market generated by electric propulsion is Roei Ganzarski, CEO of MagniX, the Redmond, Washington-based company that is actively pursuing pure electric power for the commercial and military markets. Ganzarski reports that by 2020, MagniX expects to certify its Magni250 and Magni500 engines, rated at 375 and 500 hp, respectively.

“We are working with OEMs that are designing new electric aircraft, but there is also a potential market for conversion kits to enable owners of existing aircraft to convert their aircraft to all-electric from traditional powerplants,” he explains.

The initial target for the conversion kit, says Ganzarski, is the Cessna Caravan, a single-turbo-prop-powered utility aircraft, which is a mainstay of the short-haul commercial cargo market. It will use the Magni500 to replace its Pratt & Whitney Canada PT6. A first flight is slated in 2019, with certification by 2022. “The Caravan’s typical day-to-day operation is 100 mi. or less, making it an ideal testbed for the electric motor we are developing, which we anticipate would have a range of 100-200 mi.,” he notes.

For electric aircraft, the battery is at the core. The problem is that once you go beyond light aircraft, batteries are no match for jet fuel, which has 50 times the power density of today’s batteries. This means that both fully electric and hybrid-electric propulsion will not be viable anytime soon for large, long-range aircraft, according to Tim Smith, Collins Aerospace president for power and controls. “Electric propulsion trades more favorably for smaller aircraft.”

For example, all-electric propulsion for a 12-passenger aircraft flying a 500-nm mission would require battery power density capability to improve by a factor of approximately six times, says Smith. “We expect this to continue to improve, since so many companies are investing in battery research and development,” he says. “In fact, current projections show the power density of batteries improving by a factor of three times over the next 10 years.”

Lithium-ion provides the highest gravimetric and volumetric densities available today, reports Nikhil Sachdeva, a senior consultant at aerospace consultancy Roland Berger.

“The technology has improved rapidly over recent years due to investment by automotive players to develop electric vehicles (EV),” he says. “Future production of EVs is also expected to lead to continued advancement in technology, improvement in densities and reductions in cost.”

Sachdeva adds that today, the best-in-class Li-ion batteries can achieve upward of 300 Wh/kg, which is possibly enough for small aircraft. “Our estimates suggest a regional aircraft would need a battery with a gravimetric density of 500 Wh/kg at the pack level to achieve a range comparable to today’s levels.”

MTU states that if battery-storage capacity continues to improve, smaller, short-range regional aircraft, powered by electric engines could enter service in about 30 years. For a limited-range, single-aisle aircraft the size of an Airbus A320, battery energy capacity of over 2 kWh/kg will be required, along with motors based on high-temperature semiconductors. Currently, battery energy density is about 0.25 kWh/kg, although the potential is there to increase density to 1 kWh/kg, based on laboratory-scale concepts, MTU says.

IT’S A MATTER OF BATTERIES

Paul Seidenman

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Changing Times

CFM56 maintenance is still on the rise—and will not peak until the mid-2020s

Sean Broderick Washington

CFM International is seeing a “market shift” in how customers use its aftermarket services, with more Leap-family customers opting for customized, long-term agreements, a top Safran executive says. While the change is coming, the company’s near-term services business will continue to be dominated by CFM56 work, as shop visits for the venerable narrowbody engine are not expected to peak until the middle of the next decade.

“This is really a market shift, an increase in demand from customers for long-term services contracts providing maintenance-cost predictability,” says Francois Planaud, Safran Aircraft Engines executive vice president of services and MRO. Planaud says 28% of Leap engines sold to date have long-term service agreements (LTA) attached. The figure rises to 65% when only the in-service fleet is counted. He expects it to reach 65-70% eventually, reflecting new deals from customers that have bought the engine but not yet set up their MRO plans.

“We have a lot of discussions with customers who have ordered Leap engines, that enter into service [agreements] later down the road,” he says. “So they still have some time to finalize their maintenance schemes.”

The GE-Safran joint venture books two types of long-term agreements: engine service per flight hour (ESPH) and engine service per overhaul (ESPO). Both offer similar benefits to operators, especially predictable costs over the contract’s life, which is typically 8-12 years. The primary difference is that ESPH deals are paid on a per-flight-hour basis, while the ESPO payments are due at the time of each shop visit. In each case, baseline overhaul costs are negotiated in advance; the only difference is when the customer pays.

“The price has been negotiated, and the cost-management side really becomes the main driver for the MRO provider through time on-wing and maintenance cost management,” says Planaud. “This is really a trend of the market to request that increased scope of services.”

Safran says 75% of its Leap LTAs are ESPO agreements, while the rest are ESPHs. Customization goes beyond fleet size and often includes add-ons, such as spare engine leases and engineering support.

The Leap overhaul ramp-up will not come for several years, but otherwise will mirror the new-engine delivery stream that is underway. After delivering just 76 Leaps in 2016 and 459 in 2017, CFM was on track to top 1,100 deliveries in 2018 as the year wrapped up, surpassing legacy CFM56 annual deliveries for the first time. Leap shop visits are projected to ramp up sharply starting in 2022-23. Safran projects annual Leap shop visits will surpass 1,000 in 2025.

Meanwhile, CFM56 aftermarket activity is still nearly a decade from its peak. Less than half of all CFM56s are under LTAs, and the family’s two most popular members, the -5B that powers Airbus A320ceo-family aircraft and the -7B that is the Boeing 737NG’s sole-source powerplant, make up about 80% of the 28,000 CFM56s in service. Of the 22,800 -5Bs and -7Bs in service, 60% have not had their first shop visit, and 30% have been overhauled just once. In 2025, 20% of the estimated 22,000 still in service will have their first shop visit ahead of them, while 50% will have already had one.

Continued strong demand for pas-
Passenger lift means airlines are pushing their existing equipment longer, which drives aftermarket spend. Safran now projects that peak annual CFM56 shop visits will top 3,000 in 2025.

“The two first shop visits are really the main contributors in terms of revenues,” Planaud says. “Those engines that are quite young have heavier work scope, full performance restoration and life-limited part consumption.”

Safran’s spares-sales volume is increasing as well. The company, sharing its updated outlook at its Capital Markets Day last month, is now projecting that 2022 CFM56 spares sales will be 3.7 times higher than the total generated in 2010, at the bottom of the last recession. At its last Capital Markets Day, in March 2016, the company forecast its 2022 CFM56 spares revenue would be triple the 2010 figure.

“We have benefited the last two years from quite strong tailwinds arising from very solid traffic growth, high demand, very high utilization of our products and the financial situation of the airlines that have enabled them to invest in the maintenance of the engines,” Planaud says.

The company sees annual spares revenue increasing in the high single digits for the next several years and peaking around 2025. By then, some 6,000 engines in the 20,000-strong fleet will be operating with at least two shop visits. Depending on demand for lift, this will either help create a bubble of late-life shop visits and spares sales or a flood of used parts to support younger engines.

**CFM56-5B/-7B Shop-Visit Outlook***

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<tr>
<th>Year</th>
<th>Engines</th>
<th>No shop visit performed</th>
<th>1 shop visit performed</th>
<th>2+ shop visits performed</th>
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<td>60%</td>
<td>10%</td>
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<tr>
<td>2020</td>
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<td>40%</td>
<td>30%</td>
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<tr>
<td>2025</td>
<td>~20,000</td>
<td>20%</td>
<td>50%</td>
<td>30%</td>
</tr>
</tbody>
</table>

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- Abdol Moabery, President & CEO
  GA Telesis, LLC

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Countdown to 2020

Staggered FAA and EASA due dates help, but not all operators likely to meet ADS-B ‘Out’ deadlines

Paul Seidenman and David J. Spanovich San Francisco

On Jan. 1, 2020, airlines operating in U.S. airspace must be in compliance with the automatic dependent surveillance-broadcast (ADS-B) “Out” mandate, regardless of country of registration. A similar requirement goes into effect in Europe on June 7 of next year. With the deadlines fast approaching, a considerable retrofit market continues to exist, as numerous aircraft are still noncompliant.

Citing FAA statistics valid as of Nov 1, 2018, Terry Flaishans, president of ACSS (Aviation Communication & Surveillance Systems), in Phoenix, reports that some 3,300 aircraft operated by U.S. carriers have been retrofitted for ADS-B Out, out of a total U.S. retrofit market estimated at 5,000-6,000 airline-operated aircraft.

“U.S. carriers have generally been more proactive, globally, with ADS-B Out retrofits, thanks to the FAA’s ‘Equip 2020’ program, which, starting in 2016, has helped airlines as well as general aviation aircraft operators, prepare to meet the mandate,” says Flaishans.

In Europe, a significant number of aircraft may not meet the June 7, 2020 deadline, according to Alexander Krause, product sales manager for avionics and flight deck solutions at Lufthansa Technik in Germany. As Krause reports, the latest Eurocontrol survey (ADS-B Implementation Plan—SESAR Deployment Manager; Nov 15, 2018) shows that more than 7,750 aircraft are affected by the mandate. Of those, the survey analyzed data from more than 3,700 aircraft and based on that analysis, an estimated 15-25% will not be compliant in time.

ADS-B Out automatically communicates an aircraft’s position, within a specific airspace, to air traffic controllers via a system of satellites and ground stations. This gives controllers a more precise, real-time view of the aircraft’s location, altitude and airspeed data than conventional radar-based systems, enabling more efficient flow control of a larger number of aircraft.

ADS-B Out compliance requires the installation of a complex system of multiple line-replaceable units (LRU) to be updated and certified, according to Kurt Kraft, vice president for modification and engineering for Boeing Global Services. “The ATC Transponder, GPS and [traffic collision avoidance system] LRUs are required to work seamlessly with one another, and different versions may be required by the different mandates,” he explains, adding that LRU procurement is typically managed between the airline and avionics supplier. Boeing, notes Kraft, provides its customers with a service bulletin for ADS-B Out modifications.

As more information and updated equipment have become available, Boeing has kept its customers informed of their options, Kraft says.

“Many airplane configurations required a substantial amount of wiring updates, so stand-alone wiring packages were offered that allowed customers to incorporate the needed wiring during already scheduled maintenance activities, with the option to complete the modification once the ADS-B Out equipment was procured,” he says.

SUPPLIERS ARE READY

Even with the large number of noncompliant aircraft at this late date, suppliers appear to be in a position to fulfill orders in advance of the mandate, says Mark Lynch, head of engineering for aircraft lessor GECAS. However, he cautions, there may be issues with orders placed after March 2019. Another concern could involve the number of float units available to support the ret-
Hi
According to Krause, Lufthansa Technik offered price breaks for early retrofits, but interestingly enough, not many of its customers took advantage of them. He attributes that to the fact that there were “reasonable doubts” as to whether the mandate’s European deadline would be extended.

“Airline operators have waited too long, hoping for an extension, and now many MRO shops have already reached their capacity limits for the next year,” says Krause. “Everyone not equipped yet should take immediate action and contact their local MRO for reserving the last remaining [slots] throughout 2019.”

Lynch, at GECAS, also warns that MRO schedules for ADS-B Out installations are filling up: “MRO capacity is already extremely tight, and getting access to a slot for a standalone modification may be difficult.” In that regard, Lynch says that not all aircraft will be ready for ADS-B Out by the deadline. “What is not clear is whether this will be a few individual aircraft or a more widespread issue,” he says.

MAJOR AIRLINES

Major airlines appear to be on track to meet the mandate. “At American Airlines, we have been working closely with our vendors for over two years to obtain ADS-B Out compliance,” says Ron Thomas, managing director of flight operations. “Some units were purchased new, while others were upgraded.”

The modifications, Thomas explains, are being accomplished with planning for them contingent on the age of the aircraft. Aircraft with all the hardware and software provisions in place can be upgraded to ADS-B Out compliance during an overnight check. But those with some or none of the provisions need to be completed either in a special maintenance visit or combined with another maintenance event. In some cases, he states, that can take around 100 labor-hours to complete.

Thomas adds that nearly all of the carrier’s fleet needed upgrades, with the exception of its Boeing 787s and other recent new deliveries, compliant out of the factory. “Our oldest 737, 757, 767 and Airbus A319, 320 and 321 aircraft require the most work.”

In general, the FAA has been “very comfortable with the equipment compliance rates” for ADS-B Out by the airlines, says Chuck Cook, general manager for communications, navigation, surveillance and technical programs for JetBlue Airways in New York. “JetBlue, for example, signed contracts with suppliers early enough to assure having the necessary equipment to meet the mandate,” he explains.

JetBlue bundled the installation of the ADS-B Out equipment with heavy maintenance checks. “We looked at our preexisting heavy maintenance planning and scheduled the ADS-B Out installations at the time we knew the aircraft would be out of service,” says Cook. “If we were to have done standalone ADS-B Out installations, each aircraft would have been kept out of service for about two days.”

Cook reports that JetBlue’s entire fleet of 260 aircraft—Airbus A320/321s and Embraer 190s—is slated for ADS-B Out compliance by September.

Interestingly, JetBlue will be ADS-B Out compliant under the FAA’s Exemption 12555, which allows for the continued use of older types of GPS navigation receivers already installed on some aircraft, Cook points out.

The exemption, he reports, was granted because GPS multimode receivers, with a higher precision level than those in use today, would not be available in large enough quantities for the transponders by the 2020 due date. Under the exemption, the airlines have a five-year window to upgrade, with expiration in 2025.

**ADS-B Out Mandate Timing Worldwide**

<table>
<thead>
<tr>
<th>Region</th>
<th>Prior Years</th>
</tr>
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<tbody>
<tr>
<td>Hudson Bay</td>
<td>DO-260/A/B</td>
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<tr>
<td>Hong Kong</td>
<td>DO-260/A/B/FL.290</td>
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<tr>
<td>Singapore</td>
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<td>Sri Lanka</td>
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<td>Vietnam</td>
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<td>Seychelles</td>
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<td>Indonesia</td>
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<tr>
<td>Australia</td>
<td>DO-260/A/B-All Aircraft</td>
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<tr>
<td>Taiwan</td>
<td>DO-260/A/B/FL.290</td>
</tr>
<tr>
<td>U.S.</td>
<td>DO-260B-All Class A, B, C and E (&gt;10,000MSL) airspace, SBAS-like GNSS Performance</td>
</tr>
<tr>
<td>Colombia</td>
<td>DO-260B—All airspace</td>
</tr>
<tr>
<td>Europe</td>
<td>DO-260B—All IFR aircraft &gt;5,700 KG or &gt;250 KTAS Cruise</td>
</tr>
<tr>
<td>China</td>
<td>DO-260B—All airspace</td>
</tr>
<tr>
<td>Mexico</td>
<td>DO-260B—Follow U.S.</td>
</tr>
<tr>
<td>Brazil</td>
<td>DO-260B—Follow EU</td>
</tr>
</tbody>
</table>

Exemption 12555 - Allows SA-On (with Prediction Tool) and SA-AWARE

Source: Collins Aerospace
Inside MRO20 lines, we have been working closely with meet the mandate. “At American Airlines, major airlines appear to be on track to be a few individual aircraft or a more widespread issue,” he says. Lynch says that not all aircraft will be ready for ADS-B Out by the deadline. Lynch, at GECAS, also warns that airline operators have waited too comfortably with the equipment compliance rates” for ADS-B Out by the deadline would be extended. Lynch says that not all aircraft will be equipped yet should take immediate action and contact their local MRO shops. He attributes that to the fact many of its customers took advantage of retrofits, but interesting enough, not many MRO shops have already said to whether the mandate’s European aspects may be difficult.” In that regard, the modfications, Thomas explains, “Some units were purchased new, while others were upgraded.” According to Krause, Lufthansa currently many MRO shops have already Modifications need to be completed either in a special maintenance visit or combined with another maintenance event. In some cases, he states, that can take around 100 labor-hours to complete. Some carriers’ feet needed upgrades, with some or none of the provisions and software provisions in place can be upgraded to ADS-B Out compliant under the FAA’s Exemption 12555, which allows for the continuation of ADS-B Out installations at the time we knew we absolutely needed the equipment with heavy maintenance checks. “We looked at the ADS-B Out equipment with heavy maintenance during an overnight check. But we planned for that and software would be in place before the aircraft would be out of service,” says Cook. “If we were to have done the install at the time, we would have had to take that aircraft out of service for about two days.”

Interestingly, JetBlue will be ADS-B Out compliant under the FAA’s Exemption 12555, which allows for the continuing use of older types of GPS navigation 손실금송자 위주 for them contingent on the age of the aircraft. Aircraft with all the hardware and software provisions in place can come together!
End of an Era
Monarch Aircraft Engineering enters bankruptcy and is dissolved

James Pozzi London

After a turbulent 15 months that saw the collapse of its parent Monarch Airlines and the subsequent challenges of rebuilding its third-party customer base, Monarch Aircraft Engineering Ltd. (MAEL) entered bankruptcy on Jan. 4, resulting in the immediate loss of more than 400 jobs.

MAEL’s board of directors appointed professional services company KPMG as administrators in early January to oversee the process after the company ran into financial difficulties and was unable to find a buyer.

Around 408 jobs were cut immediately, 250 of them at the company’s base maintenance operations in Luton and Birmingham, England. The former, home to MAEL’s headquarters since 1967, will also see a large cut to its staff as part of a further 158 layoffs. In the longer term, 178 staff will remain in their positions, with 83 staying temporarily to help wind down operations.

Just one day before the bankruptcy was announced, it was confirmed that MAEL’s line maintenance activities had been sold in multiple transactions for an undisclosed amount, saving 182 jobs, according to KPMG.

Most of MAEL’s aircraft maintenance jobs at London Gatwick, Birmingham, East Midlands, Newcastle and Glasgow airports were transferred to Morson Group, a UK-based industry recruitment specialist, while Storm Aviation, a domestic MRO, will take on the staff at Luton, boosting its line maintenance operations.

Some of Monarch’s roles at Gatwick, where it had been a partner in Boeing’s aftermarket network, will be transferred to the aircraft manufacturer. Line maintenance jobs at Manchester and Birmingham were transferred to Flybe’s technical division in December 2018.

As of January, KPMG is still seeking potential buyers to take control of Monarch’s continuing airworthiness management organization business, which offered fleet technical management services for Boeing and Airbus aircraft. The unit employs 27 people.

KPMG is also courting interested parties for MAEL’s Luton-based training academy, which delivered European Aviation Safety Agency Part 147 and United Arab Emirates General Civil Aviation Authority CAR 147 aircraft type training. At the time of the administration announcement, the training academy employed seven staff and operated an apprenticeship program including 53 trainees.

Operating since 1967, MAEL has endured a turbulent 15 months since its affiliate carrier Monarch Airlines ceased operations in October 2017. Despite continuing as a stand-alone entity, the demise of Monarch Airlines resulted in the MRO unit inheriting historic debts estimated at more than £100 million ($126 million).

After private equity firm Greybull Capital took majority control of MAEL about one year after the airline’s collapse, it sought to restructure the MRO’s legacy debts in the form of a company voluntary arrangement (CVA), a legally binding agreement between the company and its creditors allowing repayment of a proportion of debts over a set period. This followed speculation about a possible winding-up petition (a legal order that would force liquidation) from UK tax authority HMRC over unpaid taxes, which MAEL denied.

Compounding its financial problems was the loss of in-house fleet work resulting from Monarch Airlines’ demise. At the time of its collapse, the carrier operated 35 aircraft—25 Airbus A321-200s, nine Airbus A320-200s and a single Boeing 737-800—with its own fleet accounting for around 50% of MAEL’s maintenance output.

The effects of the loss of work were felt particularly in MAEL’s winter base-maintenance schedule, with the Monarch fleet accounting for around 80% of its MRO output during the season. Despite renewing ties with Virgin Atlantic, Spanish low-cost carrier Vueling, Air Malta and long-term cargo customer DHL Express over the 2017-18 winter season, the company saw a dropoff in its customer base in the second half of 2018.

According to MAEL’s managing director, Chris Dare, the loss of customers was further accelerated by entering the CVA, which in turn influenced directors and shareholders to put the company up for sale late last year.
Building Safer Hangars

Special design features help aircraft hangars withstand extreme conditions and provide safer, more comfortable working environments

Lindsay Bjerregaard Chicago

As American Airlines prepares to officially cut the ribbon on its new $215 million aircraft maintenance hangar at Chicago’s O’Hare International Airport in early 2019, maintenance staff have been working there comfortably since December 2018, despite the city’s chilly winter weather. Like other hangars around the world in areas prone to extreme climate or natural disasters, care needed to be taken to ensure that the hangar was designed so that workers, aircraft and the hangar’s structure could withstand the worst conditions that Mother Nature could throw at it.

The 614-ft.-long hangar’s dual sliding doors on both the north and south sides of the building can cause tremendous heat loss when opened in cold weather, so architects at Ghafari Associates looked to strategic air circulation to keep operating temperatures normal. According to Ted Oberlies, senior vice president of Ghafari Associates’ aviation group, the hangar uses a combination of direct-fired heating units—essentially, large furnaces that can quickly generate a lot of heat—and high-volume, low-velocity fans to circulate heat in winter. The fans also can provide a passive cooling effect in hotter weather, which is complemented by natural ventilation when both hangar doors are open.

Insulation of hangar buildings plays a large part in temperature regulation as well. Rubb Building Systems, which specializes in hangars composed of steel structures covered in heavy-grade PVC fabric, uses a patented insulation system called Thermohall. According to Chuck Auger, marketing manager for Rubb, Thermohall consists of two layers of PVC fabric stuffed with very-high-density appliance insulation to create an insulated “blanket” that is tensioned down around a building—which keeps the hangar’s steel framework warm.

Steel itself can be problematic in the coldest temperatures. “Steel doesn’t cope well with being made very cold,” says John Harrison, design office manager for REIDsteel. Harrison says steel can suffer from brittle fractures—a serious threat when the company was constructing a hangar for Eznis Airways in Mongolia, where temperatures can dip to between -20C and -30C (-4F to -22F). The steel needed to undergo various treatment processes to prevent such fractures, and during construction components such as hangar cladding and bolts needed to be warmed up before work was performed to prevent shattering.

According to Harrison, the Eznis hangar was built with a unique nose opening between its front doors that allows work to be done around an aircraft’s nose without the need to fully open the hangar door, which would lead to excessive heat loss. The nose opening features an inflated seal around the edge to prevent air from getting in or out once an aircraft’s nose is positioned in the opening.

Snow loading is another factor that needs to be considered when building hangars in areas with extreme winters. Oberlies says the weight of snow is an
important part of structural design, particularly on wide-span hangars such as American’s. Roofing needs to be designed according to building codes based on the heaviest snowfalls anticipated in a region, and requirements can vary internationally. Although most countries accept the International Building Code, Oberlies says local requirements sometimes can be more stringent.

“I think the interesting thing is that in the U.S., most of the code requirements for buildings are what we term as ‘prescriptive’—in other words, there is no debating or justifying deviation from those codes. It lays out exactly what you must do under certain circumstances,” says Oberlies. He adds that in other countries Ghafari works in, such as Turkey, academic institutions are often involved in studying structural applications for particular building locations to come up with an engineered solution backed up by scientific and engineering analysis.

Ghafari is currently working on the world’s largest aircraft maintenance complex for Turkish Airlines at the new Istanbul Havalimani Airport—an area that sees not only cold temperatures but major seismic threats as well. The MRO complex will use an air circulation system similar to the one at American’s hangar at O’Hare, but it will also feature a radiant in-floor heating system to help keep temperatures comfortable for workers. Because the location is built right along the Marma-ra Plate in the North Anatolian Fault Zone, the hangars for Turkish Airlines need to be built to the highest standard of seismic design.

Oberlies says hangars in seismic-sensitive areas like this require structural systems with greater flexibility or ductility to absorb energy in case of an earthquake. Essentially, this comes down to requiring more steel for bracing, which increases the complexity and cost.

“Aircraft hangars are not the worst structure in the world for seismic issues. They’re very big and are actually quite lightweight for what they are,” says Harrison. “The way seismic load-

Rubb’s hangar for Hawaiian Airlines at Honolulu International Airport.
that energy and to resist any structural failure,” says Oberlies. He adds that the reverse can also occur, where wind gusts act as a vacuum that causes deflection on the structure.

In areas prone to severe weather like this, REIDsteel uses its patented Union Jack bracing system, which transfers loads from the bottom of the roof truss down to the walls. Although steelwork can generally flex and redistribute forces around itself, cladding panels fixed on a hangar’s roof can be pared off sheet after sheet if one of the panels manages to be lifted. “If cladding takes a small amount of damage, it will very quickly look like an awful lot of damage is done to the structure,” says Harrison.

Although the fabric covering Rubb hangars is strong enough to hold people or even a vehicle, it can still be prone to tearing or ripping off in hurricane-force winds. Auger says the advantage in this case is that the hangar’s frame will be strong enough to remain standing, and the fabric can be quickly and easily replaced.

Another consideration in coastal and tropical environments is damage from sunlight and salt water. According to Auger, hot-dip galvanizing a hangar’s steel framework is the best corrosion protection to prevent salt from eating away at it. Meanwhile, Auger says the company’s PVC fabric—which can deflect sunlight and heat—will last for approximately 10-15 years before degrading and needing replacement. The fabric typically lasts 20-30 years in other environments, according to Rubb.

Harnessing the Sun is one way in which Auger says the industry is innovating to improve future aircraft maintenance hangars. According to Auger, Rubb is starting to incorporate solar panels into its hangars, which can reduce or eliminate heating costs if the building is facing in the right direction.

Ghafari is incorporating a multitude of energy efficiency features into the new Turkish Airlines complex, such as solar power, a highly reflective floor system and rainwater harvesting. Oberlies says continued advancements in smart building technology such as lighting controls for energy efficiency and intelligent building-management systems will provide even more opportunities in the future.

“The other thing that will affect the operations in hangars is better Wi-Fi technology and the ability to move data wirelessly,” says Oberlies. “That’s an improvement that will increase productivity and, frankly, all the aspects of the building—including safety—will be aided by advancements in wireless communication.”

Future innovations may also improve hangar design for severe weather such as hurricanes. Harrison says REIDsteel is using 3D modeling to evaluate wind forces on hangars, and the industry has advanced over the last decade with a practice called building information modeling, which allows different trades within the same industry to easily and freely share models across different types of software. According to Harrison, 3D-modeling practices now allow REIDsteel to design strength specifically where it’s needed. “I think the advantage in 3D modeling we’re getting now to allow us to model airflows around hangars will make a huge difference in the near future and should see us build safer hangars at a reduced cost.”
The Strongest Bonds

Brazing is critical as aerospace taps new materials and additive manufacturing

Ben Hargreaves London

Brazing engineer Ed Arata has a simple answer when asked where brazing technologies are used within the structure of an aircraft: “Brazing is used just about everywhere—it’s difficult to classify.” Arata, an engineer at Morgan Advanced Materials (also known as Wesgo) in Hayward, California, which specializes in developing and manufacturing brazing alloys, says the company’s alloys are used for everything from repairing aero-engine turbine blades to making the rocket nozzles for spacecraft to constructing hydraulic assemblies.

Nick Ludford, principal project leader at The Welding Institute (TWI) in Cambridge, England, concurs that brazing is widely used in aerospace and says manufacturing and repairing turbine blades is one of the most important applications. But the technology is also used in the subassembly of sensors for pressure, temperature and speed; the construction of aluminum and steel heat exchangers; and also for manufacturing hydraulic lines on older aircraft. With an eye on the future, TWI is investigating the brazing of aerospace components produced via additive manufacturing (3D printing), he says.

HOW BRAZING IS UNIQUE

But what is brazing, and why is it used so extensively in manufacturing aerospace components? Vacuum brazing, the process typically used in the factory at Morgan Advanced Materials, enables the creation of complex components by joining parts using a braze metal or alloy. The brazing alloy has a lower melting point than the parts being joined and when heated flows by capillary action—the ability of a liquid to flow in narrow spaces without the assistance of, or in opposition to, external forces like gravity—into the space between the parts, creating an exceptionally strong, sealed joint.

In fact, anyone who has ever soldered copper pipes in their home or circuits in an electronics assembly has carried out a process similar to brazing.

Advantages of vacuum brazing, according to aerospace heat treatment and vacuum-brazing specialist Wallwork Group of Bury, England, are that it is a clean and flux-free process. Wallwork says it also produces “high-strength components with excellent dimensional stability, free of voids and inclusions, resistant to shock and vibration and able to withstand high pressures.” Brazing is suited to the assembly of multi-part, complex components and to joining dissimilar materials, including some non-metals. The parts to be joined may be produced by a variety of methods including cold stamping and forming, casting, forging, extrusion, fabrication or machining and could be made from almost any metal, alloy or even ceramics, Wallwork explains. A major advantage of brazing is its ability to join the same or different metals in a way that makes them very strong.

BRAZING’S ROLE IN AEROSPACE

Brazing is widely used within the aerospace industry for a number of reasons. These include: cost savings because multiple parts can be processed together; the fact that multiple joints can be formed simultaneously; minimum distortion to parts, as the whole assembly is heated up and cooled uniformly; and the ability to “join dissimilar materials with different coefficient thermal expansion rates, including ceramics,” says Ludford.

The technology’s evolution has been considerable. “In the early days, brazing development [at TWI] was more experimental work. Nowadays, companies are looking for process control...
and improvement and auditing of the process, systems and quality and process development,” he says.

Like Morgan Advanced Materials and Wallwork, TWI uses vacuum-furnace technology for brazing, as well as some other techniques.

The company has recently invested in a new industrial-scale vacuum furnace to support its aerospace activities. “This facility, along with other associated equipment, is specifically aligned with the requirements through process, quality controls and documentation that are required in the aerospace industry today,” says Ludford.

For example, aerospace standards that brazed components must meet include ISO9001, AS9100, NADCAP, AMS2750 Rev E and internationally recognized standards for brazing as well. “A properly designed and brazed joint will usually never fail. If it fails, something has gone wrong. Usually, once you qualify a braze process, you never think about it again. It’s the whole assembly that will fail first, and the braze joint is good for the lifetime of the assembly or component,” says Arata.

**MATERIALS, CERAMICS**

Arata and his team are designing brazes for ceramic-ceramic, ceramic-metal and metal-metal joints, including mechanical and thermal parameters as well as alloy selection for both vacuum- and hydrogen-brazing environments at Morgan Advanced Materials’ 220,000-ft² facility in Hayward, which serves as the company’s global center of excellence for joining technologies.

Braze alloy materials produced on-site are typically made from precious metals such as gold and silver. As well as manufacturing and supplying braze alloys—which can come in wire, powder, sheet, foil and paste forms—the company also provides brazing on-site as a service for customers.

Brazing is widely used within the aerospace industry, with an eye on the future in manufacturing hydraulic lines on copper and steel heat exchangers; and also important applications. But the technology is also used in the subassembly of marine- and hydrogen-brazing environments at Morgan Advanced Materials’ 220,000-ft² facility in Hayward, which serves as the company’s global center of excellence for joining technologies.

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Vacuum-brazing furnaces can handle a variety of methods including cold metal-metal joints, including mechanical and thermal parameters as well as alloy selection for both vacuum- and hydrogen-brazing environments at Morgan Advanced Materials’ 220,000-ft² facility in Hayward, which serves as the company’s global center of excellence for joining technologies.

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**MORGAN ADVANCED MATERIALS**

Arata explains that Wesgo’s (in the metals industry, the company is commonly known by its former name) background was originally as a precious metals recycler and reseller. “Our expertise is in gold, silver and platinum. We focus on high-purity materials. Gold and silver are relatively high-temperature and high-strength, and they are corrosion-resistant, too. Aerospace requires high-temperature materials with high-strength and corrosion resistance. So we can fill that niche with braze alloys.”

At TWI in the UK, nickel, silver and other precious metals are used as braze filler metals, says Ludford. Other metals used to make braze alloys at Morgan/Wesgo include palladium and titanium.

As aero-engines run hotter, engineers are interested in the potential of ceramics to allow turbine blades to operate at higher temperatures, which is key to improving an aero-engine’s efficiency. That is because less air needs to be used to cool the turbine vane and blades and can instead be used for propulsion. According to the engineering department at Cambridge University in England, most engineering ceramics can be used at temperatures greater than 1,000°C—but suffer from poor toughness and can be difficult to join. “We are interested in bonding these ceramic materials to structures within the engine,” says Arata. “Not all traditional braze alloys will stick to ceramic materials, but our active braze alloys bond metal to a ceramic in one step. Brazing means uniform heating, and we can go slow so that we do not crack the material during heating up or cooling down in the brazing cycle.”

As aerospace engine designers and engineers move toward higher temperatures within engines, new active braze alloys are being introduced that can bond metals and ceramics and allow metal to be bonded directly to ceramic without metallization. Brazing will continue to play a key role because it is difficult to mechanically bond ceramics to metal or weld ceramics to metal, Arata points out.

According to Cambridge University, coatings such as zirconia are among those being used to help increase aero-engine operating temperatures. These coatings can operate at much higher temperatures and protect the metal from chemical attack. Combined, the effects of air cooling and ceramic coat-
Brazing for Repair

In terms of MRO, inside the turbine, products known as pre-sintered preforms (PSP) from Morgan are also being used to repair turbine vanes. If a vane breaks down due to excessive heat and wear, a PSP featuring a small amount of braze alloy mixed with the parent metal is used, primarily in the turbine section, to repair vane cracks and areas of wear.

“That means there’s an alternative to creating a new casting or a new forging of the housing for the engine, for example,” explains Arata. “We can build up material, and the customer can machine back to create a new part.”

PSPs are a customized blend of superalloy and braze powders in either a plate form or specific shape that allows selective buildup of worn surfaces to be achieved efficiently, providing time and cost savings. Extrudable paste also allows for the application of PSPs in difficult-to-reach areas, while a brushable paint form is used for sealing deep or narrow cracks or micro-cracks. PSP components also require minimal post-braze machining to restore a part to its original dimensions, Morgan says. “We’re allowing some very expensive components to achieve a much longer life,” says Arata.

Futuristic Applications

The flexibility of vacuum-furnace brazing is seeing the technology find uses in other advanced aerospace applications. Britain’s Reaction Engines is one company relying on brazing technology to develop high-tech aerospace systems. Reaction Engines announced late last year that it had developed and installed a giant, bespoke vacuum furnace for brazing the pre-cooler system for its hypersonic propulsion system, the Synergetic Air-Breathing Rocket Engine (SABRE). Intended to combine the fuel efficiency of a jet engine with the high speed of a rocket, SABRE sounds like the stuff of science fiction.

The Reaction Engines pre-cooler—part of a hypersonic engine—relies on vacuum-furnace brazing to produce an intricate assembly.

It promises to power hypersonic flights that would cut a 20-hr. journey in a Boeing 747 to 4 hr., traveling at speeds in excess of Mach 5.

Central to the SABRE design are its ultra-lightweight heat exchangers (pre-coolers), which prevent engine components from overheating at high flight speeds. Reaction Engines’ engineers needed to identify ultra-lightweight but strong metals and materials as well as how to join them together. They eventually determined that manufacturing the pre-cooler—effectively a complex system of ultra-fine but very robust metal tubes—would require a specialized furnace that could precisely control a brazing process to produce a design with “unique form, geometry and metallurgy,” the company says. The pre-cooler, composed of thousands of thin-walled tubes that carry coolant, features approximately 2,000 km of microfine tubing, with wall thicknesses half the width of a human hair. Every joint must be hermetically sealed, enabling the system to reduce air temperature from 1,000°C to -150°C in a fraction of a second.

Working with engineers at Reaction Engines, Consarc Corp. in the U.S., which makes furnaces and related systems for vacuum-induction melting, vacuum-arc remelting, and vacuum precision investment casting, as well as specialty furnaces for proprietary processes, delivered a custom vacuum-brazing furnace to Reaction Engines for manufacturing the pre-cooler. Everything about the furnace—from vacuum capability to its temperature control—has been calculated to ensure exact, repeatable results.

The result is a unique furnace that can quickly and accurately heat and cool modular assemblies containing large quantities of delicate tubing within controlled and repeatable conditions. The scale is part of what makes the furnace unique: Its hot-zone charge size is one of the largest of its kind in the world, Reaction Engines says, measuring 2.5 m (8.2 ft.) in diameter and 1.5 m high. “The sheer size ensures that the furnace will accommodate not only the pre-cooler’s test component but also the sections that will ultimately comprise the full-scale production version of SABRE,” Reaction Engines says.

Arata of Morgan notes that brazing is an economical technology for very complex assemblies such as Reaction Engines’ pre-cooler. “We have some customers that have 1,000 joints in one assembly. You put it in a vacuum furnace, and 4 hr. later it is complete.”

Brazing is also very good at joining different thicknesses of material as well as dissimilar materials such as metal to ceramics or steel to nickel alloys in aerospace applications. Arata agrees with TWI that the brazing of additively manufactured components is only going to increase in importance in the future.

“The big thing everybody is talking about is 3D printing. When you look at some of the materials that have emerged in the last five years, they are only going to get better and better. And there is going to be a need to bond those materials, whatever blend they are,” Arata says.

Brazing technology is also supporting the development of honeycomb metals for aerospace and the increased introduction of composite materials, he concludes.
Brazing New Trails

Lindsay Bjerregaard Chicago

1. Brazing Alloy Supplier

Company: Aitmek
Specifications: Auburn, Massachusetts-based Aitmek supplies precious and nonprecious metal brazing alloys for component manufacture and repair in a variety of configurations such as powder, paste, wire, foil and tape. New products from Aitmek include resistance micro-welding equipment and automation solutions for braze setup operations. The company recently automated joining processes not previously offered in the industry and is rolling out a new level of vendor-managed inventory programs to help customers reduce supply chain costs.

mrolinks.mro-network.com/company/aimtek-inc

2. One-Stop Component Shop

Company: StandardAero Component Services
Specifications: StandardAero Component Services provides repairs across 7,000 components and more than 35 engine platforms, including a variety of components requiring brazing—such as shroud hangers, vane segments, ducts and seals. In addition to process capabilities ranging from nondestructive testing and inspection to composite repair and painting, the company offers brazing, coating and heat treatment. The company, which operates from nine international locations, recently expanded its capability in the U.S. with major expansions of its component-repair facilities in Miami and Cincinnati.

mrolinks.mro-network.com/company/standard-aero-component-services

3. Flux and Alloy Specialists

Company: Superior Flux
Specifications: Superior Flux offers a range of brazing, soldering and welding flux products tailored for aerospace MROs and OEMs. Superior Flux’s new titanium brazing fluxes and alloys enable customers to torch braze titanium-to-titanium—as well as other alloys—in an open-air environment, which it says is unique in the industry. In addition to brazing, soldering and resin fluxes, Superior Flux supplies solder and brazing alloys of various specifications. The company, which has been manufacturing flux since 1932, fulfills orders of any size and ships worldwide.

mrolinks.mro-network.com/company/superior-flux-mfg-co

4. In-House Engineering Capabilities

Company: Nordam
Specifications: Nordam performs vacuum-furnace brazing services for stainless steel and nickel-based engine exhaust components to OEMs, airlines, MROs and military customers. Over the past five years, Nordam says it has returned more than 3,000 exhaust components to service. The company specializes in honeycomb-core, brazed repairs for a variety of engine types and has extensive engineering capabilities, including multiple vacuum-braze furnaces and in-house, metallic-core machining. Nordam says these capabilities allow it to develop its own out-of-manual repair work scopes and expanded services, which reduces cost for customers.

mrolinks.mro-network.com/company/nordam

5. Turbine Engine Brazing Products

Company: Vitta
Specifications: Vitta specializes in the manufacture of high-temperature nickel brazing materials and products used for manufacturing, overhauling and repairing turbine engine parts and assemblies. Vitta’s Braz-Rope is currently being used in

Go to MROLinks.com for more information.
brazing assemblies in GE's Leap engine, and the company says its brazing tapes allow a more uniform and consistent application of brazing alloys to the cells of honeycomb seals. Vitta is approved by all major aerospace engine manufacturers and says it can customize products to specific customer requirements.

mrolinks.mro-network.com/company/vitta-corp

6. Full-Service Brazing and Heat Treatment

**Company: Accurate Brazing**

**Specifications:** Accurate Brazing is a full-service vacuum brazing and heat-treating provider that has been in business since 1989. With a focus on supporting aircraft, ground-turbine and power-generation markets, the company's specialties include end-cover, nozzle and cartridge assemblies for fuel delivery systems. Its facilities in Connecticut, New Hampshire and South Carolina are able to heat and treat materials including copper, stainless steel and super alloys.

mrolinks.mro-network.com/company/exotic-tool-welding-inc

The company has a continually expanding certification and approval list ranging from Boeing and Rolls-Royce to Honeywell and Raytheon.

7. Boeing's Next-Door Neighbor

**Company:** Exotic Tool Welding

**Specifications:** Exotic Tool Welding has been providing precision welding, brazing and light fabrication services for aerospace customers in the U.S. and Canada for more than 40 years. The company, which received Boeing accreditation in the early 1980s, has a 10,000-ft² facility next to Boeing's plant in Everett, Washington. In addition to its National Aerospace and Defense Contractors Accreditation Program (Nadcap) accreditation for brazing, obtained in 2005, the company is certified in tube brazing, silver brazing and brazing low-carbon, low-alloy or austenitic steels.

mrolinks.mro-network.com/company/address-tool-welding-inc

Oman Air, the National carrier of the Sultanate of Oman located in Muscat, Oman is part of the Oman Aviation Group. As part of the Oman Air's policy, all tenders/pre-qualification invitations are floated through Supply Chain Management Department. Accordingly, we shall be floating our Pre-Qualification Invitation (PQI) for the following projects:

- **PQI 1** - Aircraft Structural Repairs (Tender is floated and closing date is 14th January 2019)
- **PQI 2** - Long Term Agreements for supply of C&E parts
- **PQI 3** - Non Contracted Rotables for CFM56-7 engine and GTCP131-9B APU
- **PQI 4** - Aircraft and Engine Rotables and Component Overhaul
- **PQI 5** - MRO to supply C checks (PACA AMO Approval and EASA or FAA is Mandatory)

Prequalification will be based on certain mandatory and non-mandatory criteria and successful companies will be registered and invited to participate in the tendering process or to provide their quotations as per requirement.

You may contact us through the following email address:

engineeringtenders@omanair.com

Interested parties for all or any of the above tenders when floated shall mention the respective subjects (PQI, PQ2 etc.) in their e-mail and send to the above mentioned email address.

The e-mail shall be responded to when the respective tender is floated accordingly.

For further information, please contact:

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Best Practices Are Not Universal

MRO providers must consider local conditions

You are a global MRO provider home-based in temperate North America or Western Europe. One of your shops is located in a tropical emerging market where your local workforce spends an average of 2 hr. on the road just to get to work.

Is the human factors approach at your home base really effective in this environment?

One of the key trends in commercial aviation over the past decades has been globalization. This has applied as much to OEM supply chains as to operator alliances. Similarly, over the past decades, leading MRO providers have grown from being regionally focused to becoming truly global players. MRO industry leaders are characterized not only by global market reach but by global networks of local MRO shops.

As leading MRO providers have developed into global operators capable of delivering identical turnaround times and quality levels across globally distributed sites, a key performance driver has been the rollout of home-base best practices to local MRO shops. This best-practices-based operations strategy has proven to be highly successful with regard to the nuts-and-bolts areas of MRO such as hangar and shop facility design, tooling and equipment, maintenance procedures, work flow and IT systems. However, in the area of safety management and its underlying human factors assumptions, an approach predicated upon the transfer of presumably universally applicable best practices has often been less successful.

Some MRO providers have fallen into a “universal best-practices trap” as they have failed to appreciate that differences in local operating environments necessitate a locally optimized approach to human factors. Implications of adverse climatic conditions and long commuting times for workforce stress and fatigue are fairly obvious. However, there are other, more subtle environmental factors that global MRO providers need to keep on their radar screens when adapting their human factors approach to different operating environments.

To do justice to the range of different environmental factors that could impact the efficacy of safety management systems in different locations, MRO providers should consider the following Four Environmental RISC Factors (Regional, Infrastructural, Socioeconomic, Cultural):

- **Regional Environment:** Where is a particular MRO shop located? What is the prevailing climate (i.e., temperature, humidity, etc.) at that location? What implications does the climate have for workspace design? What implications does it have for realistic workforce fatigue and productivity assumptions?

- **Infrastructural Environment:** What is the condition of the infrastructure on which your workforce relies to commute to and from work? Considering the state of infrastructure, what are realistic commuting times? How predictable are commuting times for your employees? What implications do long commuting times have for fatigue management and shift-schedule design?

- **Socioeconomic Environment:** What are typical standards of living for your local workforce? How widespread is ownership of personal vehicles? Are fatigue and stress due to long commutes exacerbated by lack of reliable and comfortable (i.e., air-conditioned) public transport? Are typical living circumstances of your workforce (type of housing, family size, etc.) such that post-night-shift rest and regeneration during the daytime are at all realistic? What would be the implications for your operating model and shift schedules?

- **Cultural Environment:** What are the defining characteristics of the national culture in which your local MRO shop is embedded? Would a local employee feel comfortable speaking up and reporting a maintenance error? Would a local employee push back against her/his superior? What would be your strategy to elicit candid feedback from your local workforce? What implications does the local culture have for models of good leadership and effective communication?

Global MRO providers ignore the Four Environmental RISC Factors at their own peril when optimizing their human factors approach for different operating environments. Keeping the Four Environmental RISC Factors on one’s radar screen becomes even more important considering that a significant share of future MRO industry growth is forecast to occur in operating environments that arguably are very different from the home bases of most global MRO industry leaders.

To paraphrase Mark Twain: “To a man with a rivet gun, everything looks like one type of fastener.”
Some MRO providers have fallen as they have failed to appreciate that universal best practices are not the answer. There is no single method that can work universally — each is specific to the situation. The human factors approach predicated upon the underlying human factors assumptions, of safety management and its underpinning of productivity assumptions?”

Are Not Universal Best Practices
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Roll out of home-base best practices
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turnaround times and quality levels
will be accomplished only
by global market reach but by global
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becoming truly global
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Chinese Boeing 737 completion plant built by Boeing and Comac has handed over its first aircraft, less than two years after construction began at the site. Boeing expects the facility to quickly reach its designed capacity of 100 deliveries a year, though it is beginning work at a cautious pace.

The plant’s staff spent about five weeks working on the first aircraft, a 737 MAX 8 that had flown there from Seattle on Nov. 6. Air China took delivery on Dec. 15—from Boeing, not from the joint facility.

Boeing said in announcing the first delivery. Painting to the high standard expected for new aircraft may be the greatest challenge, the head of Boeing’s Chinese operations, John Bruns, told Aviation Week in November. 

The Boeing-Comac facility does not hand aircraft over to customers. Instead, it returns them to Boeing, which must take responsibility for delivering its products from another facility at the same site. Boeing pays the joint facility for completion services; the arrangement is the same at Tianjin.

Customers will all be Chinese, and at first will all be airlines, Bruns says; aircraft bought by lessors on behalf of Chinese airlines can be accommodated later. Chinese demand for 737s, one-third of all that Boeing builds, is enough to keep the plant working at its designed capacity of 100 aircraft a year. China received 201 Boeing aircraft in 2017, of which about three-fourths were 737s. In early December, the company expected to deliver 200 aircraft of all models to Chinese customers in 2018; by the end of the third quarter it had delivered 153.

Construction of the facility began in April 2017. It has been “built in partnership with the Zhejiang provincial and Zhoushan municipal governments,” says Boeing. Occupying 66,000 m² (710,418 ft.²), it is designed to handle all versions of the 737 MAX.

Airbus’ completion center for wide-body aircraft at Tianjin is initially handling A330s, though it is eventually expected to also work on A350s. The OEM has a final assembly plant for the A320 family at the same location.

The amount of work done at Zhoushan and the rate at which it delivers will steadily rise. Capacity will not be reached in 2019, Bruns told Aviation Week. But he added: “I would imagine it won’t be too long after that.”

Not much technology is transferred by setting up a completion center, since the processes are part of what any large maintenance facility does in aircraft overhauls. Bruns emphasizes, however, that the quality must be higher: Customers expect a new aircraft to be perfect. Getting painting absolutely right will be perhaps the biggest challenge.

For customers, an advantage of having a local completion center is that employees do not have to spend so much time away from their usual duties to take delivery of aircraft.

Establishing a completion center helps Boeing even up an advantage that Airbus has enjoyed in the always political game of selling commercial aircraft to China. Now both companies are doing some final work on aircraft in the country, although the Airbus final assembly activity is deeper. Upstream, Airbus also contracts for outer wingboxes from Avic.

For both companies, however, the Chinese operations help satisfy demand. To meet A320-family production targets, Airbus needs the four per month that the Tianjin factory has been assembling; the plant is moving up to six a month, which company officials have said should not present great difficulty. The factory shifted to the A320neo in 2017.

For Boeing, Zhoushan relieves a shortage of places for parking aircraft at Renton, Washington, home of the 737 program. Freeing up space there was a factor in the decision to set up at Zhoushan, the company says.
Muilenburg has much to smile about. Since taking over leadership of the world’s largest aerospace and defense manufacturer in mid-2015, the 55-year-old has seen Boeing grab a bigger share of the profits in the $370 billion-a-year commercial aircraft industry and bounce back in defense with a series of high-profile wins. Challenges ramping up narrowbody airliner production and delivering the U.S. Air Force’s KC-46A tanker have made little dent in the company’s financial performance.

Of course, there are questions about the launch of Boeing’s next all-new airliner, its squeeze on the supply chain, the risk of increased vertical integration and the long-term costs of bidding low to win key defense business. But the aggressive course Muilenburg has charted is only gathering speed.

The creation of a stand-alone Global Services operation as a third business pillar that aims to generate $50 billion a year in aftermarket revenue by the mid-2020s has served notice that Boeing will make money on its airliners not just at the point of sale but throughout the 25-30 years they are in operation. It is a transformative shift away from the way the industry has done business for decades.

Boeing has further roiled its supply chain by insourcing more aircraft components, most notably the composite wings on the 777X but also avionics and nacelles and—via joint ventures—seats and auxiliary power units. In October, the company acquired KLX, a leading aviation parts distributor, for $4.25 billion, and two months later finalized the terms of a $4.2 billion deal to acquire
Muilenburg (right) with Steve “Bull” Schmidt, the chief test pilot for Boeing’s T-X jet trainer, which was chosen for a $9.2 billion U.S. Air Force contract in September.
a majority stake in the commercial division of Brazilian aircraft manufacturer Embraer (although the politically sensitive deal won’t close for months). And Boeing moved closer to a go-ahead in 2019 to develop the new midmarket airplane (NMA).

“The guy is intensely focused on what he wants to achieve,” says Kelly Ortberg, CEO of United Technologies Corp.’s Collins Aerospace, a leading supplier to Boeing. “His footprint is felt in the industry.”

In defense, Boeing resorted to surprisingly low bids to sweep competitions in recent months for three multi-billion-dollar Pentagon contracts: the MQ-25 unmanned refueling tanker, Huey helicopter replacement and T-X trainer. While some analysts question how the company will ever turn a profit on those programs, the wins reinvigorated its Defense, Space and Security operation in St. Louis, ensuring that Boeing will be around to bid when the Pentagon launches a sixth-generation fighter program.

Boeing’s big year was not without setbacks. Progress on the late and over-budget KC-46 tanker program remained painfully slow. The company also lost a high-profile trade dispute with Bombardier, supplier shortfalls temporarily slowed assembly of Boeing 737 narrowbody jets, and questions about an Oct. 28 crash of a Lion Air 737 MAX 8 put Boeing under a negative media spotlight.

On the plus side, Muilenburg has managed to stay on the good side of volatile U.S. President Donald Trump, who initially accused Boeing of bilking U.S. taxpayers on an Air Force One replacement contract. Muilenburg has so far kept the company out of a nasty trade war between the U.S. and China, a key customer for passenger jets. And Boeing has satisfied a vital stakeholder: investors. Shares were trading 157% higher under Muilenburg’s leadership as of Dec. 31 (see graph below), and the company has returned hordes of cash to shareholders, announcing on Dec. 17 another 20% increase in its dividend and authorization for up to $20 billion for share repurchases.

Muilenburg also has firmly fixed one eye on the future. “I’m convinced that the first person that gets to Mars is going to get there on a Boeing rocket,” he has famously said.

Boeing acquired aviation autonomy and robotics powerhouse Aurora Flight Sciences in late 2017, and its HorizonX operation seeds investments in next-generation technologies through acquisitions, partnerships with “nontraditional” entities and work on disruptive business models and technologies. Muilenburg will talk overtime about futuristic endeavors such as hypersonic travel and how he plans to keep the 102-year-old company and its 140,000 employees relevant for decades to come as the pace of technological change accelerates.

“It’s not going to be all that long before you can connect any two city-pairs in the world in a couple of hours, and Boeing is going to be at the leading edge of that capability,” he tells Aviation Week. “Imagine a Mach 5, Mach 6 transportation capability. It’s not decades and decades away; that’s kind of in a 10-year horizon.”

Aviation Week editors annually select a Person of the Year. The recognition is not an honor, but rather a reflection of someone who has had a major impact on the aerospace or aviation industries, for better or worse. Muilenburg’s mark on the industry is undeniable, and he is our pick for 2018 Person of the Year.
Muilenburg loves to talk about what he calls his “values-based” outlook. “We’re a tough competitor,” he says. “But there’s no occasion where we want our employees to be faced with a choice of competing or values. That’s a false choice.”

Those values were shaped growing up on a farm in rural Iowa. He studied aerospace engineering at Iowa State University and took a summer internship at Boeing in Seattle. “I hopped in my 1982 Monte Carlo and drove from Iowa to Seattle,” he recalls. “It was the first time I saw the Rocky Mountains. I saw the ocean for the first time.”

After being hired by Boeing in 1985, he spent 15 years in the Seattle area in a variety of program management and engineering positions on both commercial and defense programs. His father would check up on him. “He’d say, ‘Dennis, how is it going?’” says Muilenburg. “And I would describe the work I was doing as an engineer. It was different than farming, but he understood it. And then, as I got into my executive jobs, he’d say, ‘Well, Dennis, what did you do today?’ And I’d describe it to him, and he’d always pause and say, ‘Dennis, what did you actually do today?’ It always reminded me to think about the value you’re adding.”

Muilenburg’s rise through Boeing was meteoric, but his track record was far from perfect. He was director of weapon systems for the company’s Joint Strike Fighter bid, which lost to Lockheed Martin. He was Boeing’s program manager on the Future Combat Systems, a massive U.S. Army-led network-centric weapons modernization effort that was canceled in 2009. And his leadership of Boeing Defense, Space and Security in 2009-13 received mixed reviews as the unit lagged some of its peers in growth.

But Muilenburg’s promotion to president of Boeing in late 2013 signaled that the Iowa farm boy was the odds-on favorite to succeed Jim McNerney, the Yale- and Harvard-educated CEO who had restored order after an era of corporate scandals and huge market-share losses to Airbus.

Muilenburg was named to the top job 18 months later.

While his talents were well known, his willingness to act boldly and take risks was less obvious. “Muilenburg’s views are unknown,” Leeham analyst Scott Hamilton wrote at the time. “He came into the presidency from the defense side and hasn’t said much about commercial. . . . What course he will chart as No. 1 will be watched closely.”

Few developments mark the modern transformation of Boeing as much as the Partnering for Success (PFS) squeeze on the supply chain and the vertical integration of certain technologies. Though PFS was conceived under McNerney, Muilenburg kicked it into high gear with what became known as PFS 2.0. That effort culminated with the signing in late 2017 and 2018 of master contract agreements with key suppliers such as United Technologies Aerospace Systems (UTAS), Rockwell Collins, Spirit AeroSystems, Transdigm, Triumph, Leonardo, Kawasaki Heavy Industries, Mitsubishi Heavy Industries and Subaru.

While PFS was originally focused on squeezing price cuts from suppliers, 2.0 and the master agreements drove further change, setting performance imperatives and requiring continuous cost-cutting and efficiency gains to ensure a place on the NMA if Boeing launches the new airliner.

PFS and Boeing’s vertical integration efforts, including into avionics, are believed to be factors in United Technologies’ recent $30 billion acquisition of Rockwell Collins, which was combined with UTAS to create Collins Aerospace. But Collins CEO Ortberg claims no grievances with Boeing. “Dennis has been very clear, he sees a big role for the supply chain,” he says. “He’s not trying to take the supply chain out.”

Michael Goldberg, a Bain & Co. partner who leads the firm’s global aerospace and defense practice, agrees. “Look at where the profit pool is,” he says. “The Tier 1 and Tier 2 suppliers for years have made substantially higher margins than the primes. He’s not trying to bankrupt the supply base; he’s just trying to get his fair share of the profit pool.”

But the squeeze on suppliers could grow tighter if Boeing launches its...
new NMA airplane. “The rules will be, ‘If you want to be on my aircraft, you’re going to pay me a royalty on some portion of your aftermarket revenues,’” predicts Kevin Michaels, managing director of AeroDynamic Advisory. “I think that’s coming.”

The question is how hard Boeing can squeeze without breaking the supply chain, as some accuse Ignacio Lopez of doing at General Motors during similar efforts in the 1990s. Not surprisingly, PFS has spurred leading suppliers to seek their own cost savings from further down the supply chain. But smaller suppliers often are not buffered by aftermarket revenues and are more fragile financially, warns Michaels. “I worry that the conditions that are cascading down the supply chain to the lower tiers could put us at or near the breaking point. They’re heaping on more risk, especially on the companies you never hear about.”

Boeing’s about-face on vertical integration—which it famously eschewed with the 787 program—also holds risks. Teal Group analyst Richard Aboulafia says the insourcing saddles Boeing with large fixed costs that would be a drag on finances if a downturn hits and commercial aircraft production slows. “Everything Muilenburg is doing is great if you believe there will never be a downturn again in this previously cyclical industry,” says Aboulafia. “I applaud him for some things, but the vertical integration is just dangerous.”

For now, though, there are few clouds on the horizon. Boeing’s commercial backlog stands at 5,873 airplanes. The big problem for the company as well as for Airbus is how they will ramp up production to meet seemingly insatiable demand for new airplanes, particularly in the Asia-Pacific region, where millions of new travelers are entering the middle class each year.

Analysts point out that the pressure to cut costs is driven in part by an intense competition between Boeing and Airbus. While inflation has risen more than 50% in the past two decades, Michaels estimates actual prices for single-aisle Boeing 737-family and Airbus A320-family passenger jets have barely gone up over the same period.

“Boeing is squeezing out 15% returns and taking enormous capital risks,” says Bank of America Merrill Lynch analyst Ronald J. Epstein. “The question I get from investors is why this is such an irrational duopoly. What would happen if both Boeing and Airbus doubled their prices? Their backlogs would be smaller, and they would be making a lot more money.”

Muilenburg’s plan is to make a lot more money by focusing on the aftermarket, which in 2018 was added to the company’s long-term forecast. Boeing projects a market for $8.8 trillion in commercial aviation services over the next 20 years, bigger than the $6.3 trillion market for sales of aircraft.

“We see a market in which airlines outsource more and more, data analytics help aircraft and airline networks become more efficient and reliable, and new technologies provide new services solutions,” Randy Tinseth, Boeing’s vice president for commercial marketing, said at last summer’s Farnborough Airshow.

With Boeing’s services revenues projected to come in around $16.5 billion in 2018, the company has a long way to go toward reaching its $50 billion target by the mid-2020s. But with Boeing controlling just 7% of the commercial aircraft services market, Muilenburg is sticking with his target.

“I think initially people said, ‘That’s really not possible,’” he acknowledges. “[There is a] long way to go, but the strategy is working.” He counts the creation of the Global Services unit as one of the most significant accomplishments of the past three years. “That was a big change for Boeing, the first

“I applaud him for some things, but the vertical integration is just dangerous.”

—Richard Aboulafia, Teal Group
Leanne Caret. “Kevin and I are at the table for the NMA, and Leanne and I are at the table together for the T-X,” he said last June.

So is it conceivable that Boeing could go the way of IBM, a company that has evolved from making industry-leading computers into a services powerhouse? That is not happening, Muilenburg says. “Aerospace machines are extraordinarily complex and technical,” he explains. “They are not easily commoditized. . . . Our OEM [original equipment manufacturer] knowledge is one of the things that gives us the strength in growing services because we understand how we can create more value for customers.”

With Boeing on the cusp of reaching $100 billion in annual revenues, Muilenburg is executing his strategy from a position of strength. He leveraged the cash generated by the company’s booming commercial airplanes business to sweep the Pentagon’s MQ-25, Huey replacement and TX contracts with ultra-low bids that pure-play defense companies could not match. But fears that such aggressive pricing is the new norm are probably overblown. “There is a fear that Boeing could go out and bid every defense contract at a loss,” Epstein says. “That makes no sense.”

Such a strategy would conflict with Muilenburg’s goal of reaching mid-teens margins for each of the company’s divisions before the end of the decade. For the CEO, it is all about catapulting Boeing into a new realm.

“One aspiration is no longer to be just the best in aerospace,” Muilenburg says. “We have to be a global industrial champion. This higher bar is part of how we’re going to win in our second century. That has expectations around financial performance and growth, but it’s bigger than that. It’s all the things we’re doing to transform the enterprise.”

Cowen and Co. analysts have declared Boeing their top stock pick going into 2019. Cowen’s Cai von Rumohr and his team see the company benefitting from gradual ramp-ups in commercial aircraft production, stable pricing, supplier concessions, no upcoming labor negotiations and 787 production shifting to the more profitable -9/-10 models.

“The current decade is far more conducive to profitable jet aircraft production than any of the prior four,” Cowen analysts write. “A key reason is that as the industry has matured, production has stabilized, with year-over-year swings currently averaging 7% versus 17-46% in prior decades. That is important, because large fluctuations limit profitability.”

Asked if he is willing to declare success in becoming a global industrial champion, Muilenburg demurs. “We can declare progress,” he says. “We have to continue to drive this innovation machine, right? The pace of innovation, the technology disruptions that are happening around us are massive.”

Muilenburg’s enthusiasm for his role as Boeing’s leader is palpable. “He’s an airplane guy; he’s part of the industry,” observes Epstein. “His excitement is real. He seems like a CEO that really likes what he does.”

Blowing Off Steam

> U.S. NAVY’S EMALS STILL MISSES CRITICAL RELIABILITY METRIC

> UPGRADES NECESSARY FOR FORD-CLASS CARRIERS TO MEET GOALS

Lee Hudson and Steve Trimble Washington

Shortly after his 2017 inauguration, U.S. President Donald J. Trump landed aboard the USS Gerald R. Ford (CVN 78) in a Sikorsky VH-3 helicopter for a pre-commissioning ceremony.

Touring the aircraft carrier’s below-deck compartments, a particular subsystem decades in the making drew his fury. As a sailor explained how the new Electromagnetic Aircraft Launching System (EMALS) would replace steam-powered catapults, Trump erupted: “No you’re not. You’re going to goddamned steam. The digital [alternative] costs hundreds of millions of dollars more money, and it’s no good.”

The memory of that encounter stayed with Trump almost two years later, as he riffed on technology during normally pleasant, morale-boosting phone calls with sailors serving overseas on Thanksgiving Day.

“Steam is very reliable, and the electromagnetic, I mean, unfortunately you have to be Albert Einstein to really work it properly,” Trump said.

Trump’s blunt criticism adds another challenge for General Atomics Electromagnetic Systems’ struggling EMALS program. Although not quite as complicated as Einstein’s views on relativity, EMALS’ reliability still compares poorly to the steam-powered system being replaced. Twenty years after entering preliminary design stage, the EMALS remains a maintenance headache and an operational speed-bump as the Gerald R. Ford prepares for a maiden deployment in 2020.

For instance, in June 2017, the subsystem averaged 455 cycles between critical failures, which is drastically fewer than the Navy’s objective of over 4,000. During the 2018 calendar year, there was an uptick of an average of 747 catapults and traps before failing, Navy acquisition executive James Geurts told the Senate Armed Services.
The era of steam on aircraft carriers began in 1950, with the British Royal Navy trialing the technology on the HMS Perseus (R51). The ship's boilers generated steam from desalinated seawater; pumped the resulting vapor into dry receivers or wet accumulators and then released it through a set of valves to drive steam pistons. The piston stroke functions as the catapult, as it flings an aircraft loaded into a deck shuttle off the ship.

The system is an ideal energy source for a ship as large as a carrier, with an inexhaustible supply of water from the ocean and enough size to contain all of the equipment. But steam technology also poses limitations. In the same amount of space in which EMALS generates 121 megajoules (MJ), the steam catapult produces a maximum of 95 MJ. Steam power also cannot be tailored to fit the weight of the aircraft, so lighter aircraft are ejected with the same force as heavier machines.

The Navy has been aware of the theoretical advantages of an electromagnetic alternative to steam for decades. Westinghouse tested the Electropult for an aircraft carrier in 1946, but the limitations of power electronics doomed such technology from full-scale development for nearly six more decades.

A new source of voltage and rising frequency for the launch motor finally made it possible to consider an electromagnetic system for aircraft carriers: the cycloconverter. In a process not unlike a steam catapult (except using electric power), the EMALS feeds power into energy storage devices, which in this case involve a set of rotors on flywheel alternators. When the alternators release that power in 2-3 sec. pulses, the cycloconverter efficiently amplifies voltage and frequency of the current to the launch motor. The cycloconverter allows the launch motor to vary the voltage and frequency, depending on the need.

The technology behind EMALS is 150 years old. The idea of moving a projectile using an electronic field is not new, Bryan McGrath, deputy director for the Center of American Seapower at the Hudson Institute and retired Navy commander tells Aviation Week.

“This technology has been known and understood for a long time,” McGrath says. “The suggestion that somehow this is splitting the atom or one of the great leaps forward of technology is just misplaced, and I think the president overdoes that.”

Critics say Trump does not understand the benefits of working through EMALS and advanced arresting gear engineering challenges. The problems are not insurmountable, and McGrath is confident the Navy and General Atomics will figure it out.

“Thirty years from now, other navies will build these ships with electromagnetic launch-and-recovery systems,” McGrath says. “We’re far from throwing in the towel on this, and the suggestion from the commander-in-chief that we [do so] . . . is unwise, and it is sort of reminiscent of this impetuous nature in general.”

The service is completing launch bulletins for a variety of aircraft, Navy Capt. Kenneth Sterbenz, aircraft launch and recovery equipment program manager at Naval Air Systems Command, tells Aviation Week.

“For shipboard operations, those launch bulletins will tell the ship at a very high level what’s required wind over deck—in other words, how much headwind is needed for the specific aircraft at that specific weight of launch,” Sterbenz says. An advantage of EMALS over the steam catapult is that the Navy can more precisely manage all those factors to launch an aircraft from the flight deck. The recovery bulletins are the inverse to arrest an aircraft, he says.

Sterbenz’s team is incorporating the lessons learned from the at-sea test period conducted by the service roughly one year ago. When asked about failures between cycle times, he says the at-sea sample set is much smaller compared to the 3,800 launches and more than 2,000 arrestments the Navy has conducted at its land-based test site in New Jersey.

In the fourth quarter of this calendar year, the Ford will have the launch bulletins and the latest software and hardware, he says.

“The main difference I’m getting to appreciate between the two systems is with the EMALS, you start with a known condition at 0 kt., and you know where to get that aircraft to, whatever its speed,” Sterbenz says.

The Navy reached an agreement in December with Huntington Ingalls Industries Newport News Shipbuilding to purchase two aircraft carriers at the same time—the USS Enterprise (CVN 80) and CVN 81. This is an opportunity for the service to make modifications to subsystem design because the Enterprise will not begin construction until 2020.
General Atomics Aeronautical Systems’ (GA-ASI) lofty plan to develop the MQ-9B SkyGuardian into the world’s first certified medium-altitude, remotely piloted aircraft for unrestricted operations in global airspace is entering a crucial phase following the release of certification requirements by its launch customer, the UK Defense Ministry.

Based on a fundamental redesign of the company’s Predator B unmanned air system (UAS), the next-generation MQ-9B is being developed to enable wider use in civil airspace with increased levels of performance and reliability. Formally launched by the UK Royal Air Force (RAF) as the Protector, the development of a “file-and-fly” vehicle is pivotal to the company’s future, says GA-ASI Aircraft Systems President David Alexander.

“There are customers right now who can’t take our airplanes as is or even bring them into their country and fly them without having to completely certify the design—so that’s the future. If we don’t do this, somebody else will. The future of unmanned aircraft is to be able to file and fly, and to get there you have to do what we are doing,” says Alexander.

The result of a five-year internally funded effort, the MQ-9B is designed to meet U.S. and NATO military airworthiness standards in the near term and FAA commercial certification standards in the long run. However, although GA-ASI’s new design has been guided by Stanag 4671—a NATO standard for unmanned aircraft derived partly from the FAA Part 23 regulations governing utility aircraft—achieving military type certification now hinges on how closely the MQ-9B complies with airworthiness requirements developed by the UK.

These requirements, numbering more than 1,700 airworthiness codes and special conditions, are enshrined in the Protector RG1 type certification basis (TCB), newly released by the UK Military Aviation Authority (MAA). The first type-certification standard ever endorsed by the UK military for a remotely piloted aircraft, the document is also believed by GA-ASI to be the first full TCB to be developed for such a vehicle.

“It’s the rule book of airworthiness compliance requirements that, once met, we have a commitment from an aviation authority that we will get a military type certificate,” says Protector UAS Program Senior Director Chris Dusseault. “This didn’t exist before we started. We believe it’s the first in the world; it’s hard to confirm, but we feel it’s the first true step,” he adds.

Development would have been easier if the TCB had existed “five years ago, when we could have started with a clean-slate design, so we had to anticipate a significant amount,” says Dusseault. “But we worked closely with the aviation authorities, and we’ve done an analysis of our design against these requirements, and we believe we are going to meet the objectives.”

However, GA-ASI “still has to develop these airworthiness artifacts and meet all the standards to their satisfaction,” he cautions. “That’s a big task and has never been done before.”

Through Stanag 4671, and guided by military and civil specifications, GA-ASI completely redesigned the Predator B’s baseline structure and systems to enable the MQ-9B to meet more stringent airworthiness requirements normally applicable to manned aircraft. This included adopting damage-tolerant, inspectable composites that incorporate an embedded copper mesh for lightning-strike protection.

Other design changes address structural consideration for the full flight envelope rather than payload stores separation, the adoption of more rigorous aircraft-level avionics and hardware certification standards, and protection from icing. Broader changes range from the introduction of a detect-and-avoid situational awareness/navigation system to overhauling the manufacturing process, supply chain and quality levels.

The specific RAF Protector configuration also includes the addition of an experimental lightning protection and deicing, the second MQ-9B prototype joined the flight-test program in September.

**UK MILITARY AVIATION AUTHORITY ISSUES FIRST-EVER TYPE CERTIFICATION BASIS FOR REMOTELY PILOTED AIRCRAFT**

**FIRST PRODUCTION-STANDARD MQ-9B TO ENTER TESTS THIS YEAR**
X-band Skynet Satcom plus a backup Inmarsat system. The vehicle will also support data-link encryption; identification, friend or foe (IFF) Modes 4 and 5; and a mission intelligence station. It will carry the Raytheon Paveway IV precision-guided bomb and MBDA Brimstone missile, too.

“Over the next three years, we will be filling out all the data for this TCB, and eventually we will present it to the MAA. On review, it will be designated with a military type cert,” says Dusseault. He adds that no significant design changes seem to be required based on a preliminary assessment of the TCB. It is not yet clear whether some retesting may be needed.

GA-ASI is also developing a satcom launch and recovery element along with a certifiable ground control station (CGCS) in which the flight management system, displays and navigation guidance are provided by Collins Aerospace Pro Line Fusion system. Development has included an automatic-takeoff-and-landing capability using a satcom data link, a feature that enables taxi, launch and recovery from anywhere in the world with a smaller ground crew and logistics footprint.

The initiative, which also included development of a portable pre-/post-flight ruggedized laptop for the ground crew, was sparked by the Protector program. “It was not an airworthiness-driven feature but is linked to UK requirements. As a smaller force, they wanted to explore whether they could operate it with fewer personnel than the U.S. Air Force, so they’ve been the catalyst to make this part of the baseline program,” says Dusseault.

“Instead of having a ground control station, you have a laptop. The smallest team possible before was six people, three on the aircraft and three controlling. In this case, we’ve reduced it to just three people. Also, you don’t have a pilot in a forward operating location,” he adds. Automated preflight protocols developed for the laptop have helped cut the standard 45-min. pre-flight time in half.

Remote operations using the satcom launch-and-recovery capability on the MQ-9B was first demonstrated in late 2017, when personnel at GA-ASI’s Gray Butte Flight Operations Center in California controlled the aircraft via satcom data link for taxi and automated takeoffs and landings at Laguna Army Airfield in Yuma Proving Ground, Arizona. A year later, on Dec. 5, 2018, the company built on this achievement by completing the first end-to-end automated satcom land recovery flight demonstration. In this event, the laptop system was used to power-up and preflight the MQ-9B in Arizona before operators in California flew the aircraft using a satcom data link. The laptop was then used for the post-flight and shutdown after landing back in Yuma.

Development of the CGCS meanwhile continues on track. Used for the first time last October to fly the MQ-9B in Yuma, the system incorporates dual-redundant pilot/sensor operator stations and is based on an architecture that separates flight- and mission-critical functions. This allows the modification of mission software without affecting flight-critical software. Flight tests of an end-to-end automated satcom takeoff and landing recovery using the CGCS are expected early in 2019.

With the addition last September of YBC02, the second MQ-9B prototype, the flight-test program is also accelerating. The newest aircraft incorporates several features that were not available when the first MQ-9B made its debut in 2016, such as deicing and lightning protection as well as upgraded avionics and software. YBC02 has been focused on further flight envelope expansion, as well as testing flight controller updates, the CGCS and a key element of the future production version—the certified redundant control module.

The prototype, YBC01, continues testing as well and, together with YBC02, has amassed almost 450 flight-test hr. These included a record endurance flight for a Predator series of more than 48 hr. established in 2017 and a transatlantic flight from Grand Forks, North Dakota, to RAF Fairford in the UK in July. The initial production-standard MQ-9B, BC03, is due to join the test program in 2019, with a second company-owned sistership, BC04, due to join in early 2020.

GA-ASI expects to begin delivering the first of 16 production Protector RG1 to the RAF in mid-2021, with remaining deliveries running into early 2023. An additional brace of MQ-9Bs is expected to be delivered to Belgium, after the aircraft was selected for that country’s surveillance UAS role in late 2018. Australia, Canada, India and the U.S. Air Force are also interested in the MQ-9B.
The seemingly insatiable demand for unmanned aircraft systems (UAS) in the Middle East may have been satisfied by Chinese exports, but there are signs these customers are becoming frustrated by the technical limitations of those systems.

Prevented from purchasing armed U.S.-made systems such as the General Atomics MQ-1 Predator or the MQ-9 Reaper, with the Obama administration citing Missile Technology Control Regime regulations, countries such as Egypt, Iraq, Jordan, Saudi Arabia and the United Arab Emirates (UAE) turned to China to supply them with armed UAS, including the China Aerospace Science and Technology Corp. (Casc) CH-4 Rainbow and the Chengdu Aircraft Industry Group (Caig) Wing Loong family of medium-altitude, long-endurance (MALE) UAS.

In operation for several years, these UAVs have seen extensive use over Iraq, Syria and Yemen.

But a study examining the use of armed drones in the Middle East from the London-based Royal United Services Institute (RUSI) has found that the introduction of these systems has had little impact on the air power doctrines of the nations that have adopted them.

For Iraq, Jordan and Saudi Arabia in particular, the Chinese UAS are not interoperable with the Western command-and-control architectures used by those countries, relegating the Chinese-made platforms to a niche role and operating “largely in a vacuum,” which—according to researchers Aniseh Bassiri Tabrizi and Justin Bronk—is “greatly limiting their operational utility.”

These frustrations could drive some Middle Eastern customers back into the arms of the U.S. for UAVs, Tabrizi says.

Washington is trying to ease the regulations around exports of armed UAVs, with U.S. officials describing the Chinese systems as “knockoffs.”

In Iraq, one of the earliest regional customers for Chinese UAVs, compatibility with Western command-and-control systems is seen as less of a problem because the country is already operating a broad mix of air platforms from China, Europe, Russia and the U.S.

However, Iraq’s CH-4s are not integrated into the coalition intelligence, surveillance, reconnaissance and air operations picture, which the researchers say has “rendered them unsuitable” for operations where coalition ground forces are operating in conjunction with Iraqi forces.

The Emiratis have found a way around some of these limitations, but only because they have been able to purchase the unarmed General Atomics Predator XP, an exportable version of the MQ-1. Several other Middle Eastern nations have attempted to purchase the Predator XP, so far without success.

According to Bronk, the UAE has been operating the Predator and Chinese platforms together, using the more advanced camera systems on the Predator to cue targets for the Chinese UAV. The limitations of the Chinese UAS’ electro-optical cameras and the gimbals that stabilize them may have also forced the aircraft to operate at lower altitudes compared to U.S.-made systems, making them more vulnerable to ground fire, says Bronk.

Several Chinese-made UAVs have been brought down over Yemen, but it is unclear whether they were operated by the Saudis or Emiratis.

The UAE was due to take delivery of the Piaggio Hammerhead MALE UAS, but delays with the program prompted Abu Dhabi to cancel the order, and the Italian company subsequently filed for bankruptcy in November after declaring itself insolvent.

The RUSI report suggests the Chinese UAVs have had a significant doctrinal effect on Emirati military operations, including those being conducted overseas. The report states that the UAE has forward-based some of its Wing Loongs in Libya and even put them under the control of Libyan National Army forces commanded by Khalifa Haftar, which is a direct contradiction of international arms embargoes.

For all their apparent faults, the
Chinese UAVs have given Middle Eastern states a taste of the military potential of armed UAVs, and at a fraction of the cost of U.S.-made platforms. According to Bronk, aircraft like the CH-4, including ground-control systems and a weapons package, can be acquired for a third or even a quarter of the price of unarmed, U.S.-produced systems. The RUSI report states that China is “often described as a ‘no-questions-asked’ exporter of drones, often with just two criteria for its customers—dealing exclusively with states, and then prioritizing those countries that will use the platforms for counterterrorism operations.

Resupply of Chinese-made munitions is also said to be easier than restocking with U.S. Foreign Military Sales-controlled weaponry such as the Hellfire missile used on the U.S.-made UAVs. That process is more bureaucratic, Bronk notes.

The RUSI study also looked at the armed UAV activities of Iran, Israel and Turkey, all of which have independently developed unmanned platforms.

Unlike China, Iran does not differentiate between state and nonstate groups in the export of its UAVs, the RUSI report notes, and it has made deliveries to designated terrorist groups such as Hamas and Hezbollah as well as to Houthi rebels in Yemen. UAVs have also been delivered to the Syrian Armed Forces.

The RUSI report states that Iranian UAV development is a means of compensating for the vulnerabilities in its air force, which has equipment dating back to the 1970s and has struggled to remain relevant due to international sanctions. Iran has also used UAVs to violate Israeli airspace, something it could never do with its conventional airpower.

Japan’s First UH-X Flies as Subaru Plans Low-Cost Production

With the first flight out of the way, Subaru is working on three months of company flight testing for the UH-X, a military version of an upgraded Bell 412 that the company can expect to build under license until about 2040. Production engineers, meanwhile, are preparing a manufacturing line that will use processes from Subaru’s commercial-aircraft business to drive down costs.

Japan’s defense ministry has dashed hopes of another army rotorcraft production program starting up in the next few years, however. A nascent requirement for 30-50 New Attack Helicopters has been left out of a defense acquisition plan for the five fiscal years beginning April 1, 2019, although commencement of series UH-X production has been included.

The prototype UH-X flew for the first time on Dec. 25. Company pilots flew the aircraft for 55 min. from the plant at Utsunomiya, where the program is being handled, Subaru says. The UH-X is based on the civil 412EPX, developed in parallel to support the military program.

The military prototype will undergo company testing until the end of the current fiscal year, March 31, when it will be handed over to the defense ministry for customer testing. The army requires 150 UH-Xs to be built over 20 years to replace Bell UH-1Js, also built by Subaru, which was called Fuji Heavy Industries at the time. The last of those was completed in 2007, although the single-engine design dates to the 1950s.

Subaru will also build the Bell 412EPX, which is basically a 412EPI with an uprated transmission that could be certified to run for 30 min. without lubrication. That feature and two engines were needed to meet the army’s requirement to operate UH-Xs over water to reinforce outlying islands. Bell achieved certification for the 412EPX in July 2018. Subaru is integrating military equipment on that version to create the UH-X, which will eventually be given a new, permanent name.

Significant cost reductions are also being pursued, says Katsuhisa Hashimoto, Subaru’s general manager for the program. To achieve them, the Utsunomiya factory’s processes will differ in many key ways from those Bell employs to build the 412 in Canada, he said at the Japan International Aerospace Exhibition in Tokyo last November. The manager declines to specify the new production methods but says they come from Subaru’s commercial-aircraft programs. The Japanese company makes major airframe assemblies for Boeing.

Subaru undertook a succession of initiatives in 2008-15 to drive down aircraft manufacturing costs. For example, it reduced labor time spent moving parts on to, off and between tools, while also learning to quickly cut the size of purchased materials, such as blocks of aluminum to minimum sizes (AW&ST Oct. 21-Nov. 6, 2016, p. 31).

The UH-X plant will be capable of building for both military as well as civil requirements beginning in fiscal 2019, said Hashimoto. Bell and Subaru will share the global market for the 412EPX; Subaru’s territory is the Asia-Pacific region.

Building the first civil 412EPX this year will support the application for a production certificate. That unit is earmarked for delivery, but no buyer has yet been announced. Subaru and Bell will share the global market; the Japanese company’s territory is the Asia-Pacific region.

The defense ministry has requested funding for six helicopters of the type in fiscal 2019. Looking further out, its acquisition plan for the five years beginning fiscal 2019 includes 34 UH-Xs, implying average purchases of seven per year in fiscal 2020-23. Although this will be subject to annual parliamentary approval and finance ministry scrutiny, Subaru needs to build at least seven UH-Xs.
per year to complete the program in 20 years.

The company had reason to hope it would be building another Bell product, the AH-IZ Viper, or perhaps the Boeing AH-64 Apache, for the New Attack Helicopter program in fiscal 2019-23. But that requirement is now unlikely to become a firm program before 2024. Bell was one of the companies that promoted attack helicopters at the Japan Aerospace exhibition, though the ministry has gone no further than requesting information (AW&ST Dec. 24, 2018-Jan. 13, 2019, p. 48).

Japan’s current attack helicopter fleet comprises 59 Bell AH-1S Cobras, survivors of 90 built mainly by then-Fuji Heavy Industries, in 1979–2000. Ministry officials earlier told Aviation Week that the replacement program might be included in the upcoming five-year acquisition plan, the Mid-Term Defense Plan, but it was not. The document was published on Dec. 15.

There was no explanation; the item was simply not listed. It cannot now be expected before the next acquisition plan, for fiscal 2024-28.

The current force was mentioned, however. “We will reduce the combat helicopter units, which are under the direct control of each army, and review their deployments with the aim of using the aircraft effectively and efficiently,” the ministry stated in the policy document. Since the ministry’s request for information specified a possible purchase of 30-50 helicopters, the eventual reduction in numbers has been expected.

The Japan Ground Self-Defense Force comprises five armies, geographically disposed from the north to the southwest of the archipelago. No specific reason for the reduction in attack helicopter numbers was given, but the ministry has decided to shift emphasis away from meeting major-invasion threats.

“Preparation against invasion, such as large-scale amphibious landings, which was mainly conceived during the Cold War, should be maintained at a minimum level necessary to respond to changes in the future,” the ministry said. “This will be done by keeping minimum required expertise and required capacity and seeking to achieve more thorough efficiency and rationalization.” Related to this, tanks will be replaced with wheeled vehicles on the main island, Honshu.

The invasion threat the ministry referred to appears to be the prospect of Russia attempting to take at least a large part of Japan. During the Cold War, the northern island Hokkaido was seen as being at risk.

The ministry continues to be concerned about losing southwestern islands to China, as shown by references to this problem in recent acquisition programs, including UH-X. Indeed, intervention in such a campaign is one role for the intended AH-1S replacements.

Apart from Bell, possible competitors for the New Attack Helicopter are Airbus, Boeing, Kawasaki Heavy Industries (KHI), Leonardo and Mitsubishi Heavy Industries. A Japanese partner would probably be required for the foreign companies. Bell’s association with Subaru runs deep; the latter also built Japan’s 12 AH-64 Apaches. Airbus has long been a rotary-wing partner of KHI, which also built Leonardo AW101 helicopters for the navy.
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Revealed at the Consumer Technology Association’s CES 2019 show in Las Vegas, Bell’s Nexus is distinguished by six tilting ducted fans and sized to carry four passengers and a pilot. Powered by a hybrid-electric propulsion system incorporating batteries and an unspecified Safran turbine engine, the Nexus is designed to “safely and efficiently redefine air travel,” says Bell’s executive vice president for technology and innovation, Michael Thacker.

As one of five companies teamed with Uber to develop urban air taxi demonstration vehicles for trials in Dallas and Los Angeles as early as 2020, Bell is also unveiling the Nexus as part of a broader strategy aimed at applications beyond air taxis, including logistics and military missions. While the idea of air taxis is not new, Thacker says: “What is new is the emergence of technologies that enable quiet, safe, efficient, affordable urban air mobility operations at scale using small, heavily automated electric and hybrid-electric vertical lift aircraft.”

The Nexus is a preliminary product of four integrated frameworks used by Bell to help define a UAM model. “Using operational, regulatory, manufacturing and technology frameworks, we are enabling innovative technology, charting a path toward regulatory support and ultimately informing aircraft design and operating requirements,” says Thacker.

“While we are not sharing specifics on active projects today, we believe that viable commercial operations are possible in the mid-2020s,” he says. “Tomorrow’s challenges facing our population centers are not going away and will not be solved by conventional means. There is a lot of work to be done to create a viable UAM network, but we believe the future is real and possible and coming soon to a city near you.”

The Nexus is a “pretty serious aircraft,” says Bell Vice President of Innovation Scott Drennan. “[The design is] what we believe is a certifiable vehicle that makes this market real in the future. Hybrid propulsion reflects
our belief in a broader capability set. The ducts are great for noise and enable a new set of folks to approach this aircraft comfortably. We want this to reach everyday folks who have to commute to work, visit families and get from Point A to Point B.”

Sized to fit within a 37 X 37-ft. light helicopter landing site, the Nexus is targeted at a range of 150 mi. and a cruise speed of around 130 kt. Bell is aiming for a takeoff gross weight of 6,000 lb. and maximum payload capacity of 800-1,000 lb.

The cabin’s automobile-styled interior is configured with side-by-side seating for four, plus a forward single seat for a pilot. “We think that is where the market is. We think a pilot will be there initially, to help people accept the technology, but we think the pilot will eventually go away and be replaced by an autonomous system,” says Drennan. “In this ecosystem, you will find people who are bullish and some who are bearish. We are in—we are believers, and we are going to make this become real in the marketplace.”

Bell’s confidence stems in part from its extensive heritage in ducted-fan and tiltrotor designs going back to the XV-3 of the 1950s and, more particularly, the X-22 short-takeoff-and-vertical-landing X-plane of the 1960s. Adopting a configuration very similar to that of the much larger X-22, the Nexus features high-mounted ducted fans arranged in pairs.

The forward and aft fans are located on pivoting struts close to the fuselage, and the midset is attached at the tips of a centrally mounted stub wing. The single-rotor fans, each consisting of four blades and measuring 8 ft. in diameter, are housed on hubs supported within the duct by guide vanes. In helicopter mode, the ducts are tilted horizontally to generate vertical thrust, and in aircraft mode they tilt vertically to provide forward thrust. The ducts are passive lift systems and generate the vast majority of lift in airplane mode, along with the wings in the center,” Drennan says. “The duct shape generates lift regardless of what is spinning inside of it in airplane mode.”

A Safran turbine engine is housed on the upper aft fuselage and, along with batteries, provides energy for the vehicle’s hybrid-electric propulsion system. The engine exhaust is ducted aft between the twin vertical stabilizers of the aircraft’s Pi tail.

A hybrid-electric propulsion system was adopted for greater mission flexibility, says Kyle Heironimous, propulsion lead engineer for Nexus. “That does not mean we’ve closed the door on future technologies,” he notes, “so we are always keeping our eyes on the status of batteries, fuel cells and future energy storage, and a lot of technologies that we are developing for hybrid systems including electric machines, motors, generators and power electronics.”

As well as providing the turbine engine, Safran will be responsible for development of the series hybrid-electric propulsion system and drive system. The company, which began ground runs of a 100-kW hybrid-electric distributed propulsion system in mid-2018 at its Pau-Pyrenees test site in France, also recently unveiled the first of a newly developed family of electric motors up to 500 kW, and is providing a modified version of its Ardiden 3 turboshift to provide electrical power to the Boeing-backed Zunum 12-seater ZA10 hybrid-powered aircraft.

In the Nexus the turbine-driven generator will produce DC electricity, which will be transferred to motors in each duct via a redundant power distribution network. “In addition to the turbine or turbo-gen as we call it, we have a high-power, high-energy battery energy storage system that provides a redundant and dissimilar source of power to the propulsion system,” Heironimous says.

The architecture enables the battery to assist the generator’s electrical output “when the aircraft needs it during transition or maneuvers,” he says. “Also, if in the unlikely event that the engine shuts down in flight, the batteries have enough power to land the aircraft safely or potentially continue its mission and land safely. That means we don’t have to carry extra parachutes and can always land safely under our own power.”

Power from the generator and battery combine into the distribution system that feeds the six fans, each of which contains a direct-drive electric motor. “That is important because it is attached directly to the rotor system,” says Heironimous. “There is no intermediate gearbox or lube system. We are keeping it as simple as possible, and that keeps it reliable, cost-effective and safer.”

Logan, Utah-based Electric Power Systems (EPS), which led development of the lithium-ion battery pack for NASA’s X-57 Maxwell electric propulsion demonstrator, will provide the energy storage system, including batteries, power electronics, thermal management and battery management. “Batteries are always a trade between high power with low energy or high energy with low power,” says Heironimous. “But a VTOL mission needs both, which means it is a heavy battery. Only within the past couple of years have we reached the point where batteries are reaching the energy and power densities necessary to enable electric and hybrid eVTOL.”

The advanced EPS battery system makes the hybrid approach feasible and enabled Bell to optimize the size of the generator and turbine. “Using the battery to shave off the peak power demands of the mission allows us to size a smaller turbine, which is more efficient and lighter,” says Heironimous.

The Nexus will have a Thales-developed fly-by-wire flight control system (FCS) that will be “different
to anything Bell has done before in many ways,” says flight controls lead engineer Jeff Epp. The flight control system will be distributed, with centralized flight control computers connecting to remote electronics and motor controllers. For the first time on a Bell aircraft, primary flight control surfaces will be moved by all-electric actuators rather than conventional hydraulic systems. The electromechanical actuators and motor controllers will be provided by Moog.

“For the first time, we have integrated the FCS with the propulsion system,” says Epp. Flight control computers will control the motors, rotors and ducts. “The flight control computers control those motors to not only provide thrust but also to use those rotors to dynamically control the aircraft,” he adds. “That allows us to do roll, pitch and yaw control as well as use them for hover mode and forward flight.” In helicopter mode, roll, pitch and yaw control is provided by varying rotational speed on the fans and directing thrust using movable vanes in the fan ducts. In airplane mode, flight control is provided by rudders on the canted vertical tails and ailerons on the midfan duct struts.

The flight control system will also work closely with the autonomous vehicle management computer (VMC), which will be developed by Garmin. The VMC is “the brain of the aircraft,” says Nexus avionics lead Frankie Mazzei. For power management, the VMC will take information from the battery and relay it to the engine, while for navigation it will be able to take ground station commands and relay those to the FCS. “Today, that is all managed by the pilot,” says Mazzei. “The goal of the VMC at Bell is to be the ultimate pilot assistant, enhance situational awareness, reduce workload and increase safety. The end goal is to be fully autonomous.”

Bell is reluctant to detail the development schedule, but Drennan says the program is currently “somewhere between preliminary and critical design reviews.” Entry into service is targeted at the mid-2020s, with demonstrators and prototypes “phased in between now and then,” he says, adding that the first vehicles will be fully autonomous to “unlock speed in the schedule” and enable the early potential for an optionally piloted aircraft. The route to certification is undecided but “could come out of Part 23,” Drennan says.

**Record-Breaking Zephyr’s Battery Holds eVTOL Potential**

The provider of the batteries for Airbus’ record-breaking Zephyr solar-powered stratospheric unmanned aircraft says it is working with electric vertical-take-off-and-landing (eVTOL) developers on application of its high-energy-density lithium-ion cells.

Where conventional lithium-ion batteries have graphite anodes and an energy density of 300-320 Wh/kg at best, Amprius’ cells use a silicon nanowire anode and have a specific energy of 435 Wh/kg. “That’s an enormous difference,” says Jon Bornstein, president and chief operating officer of the Sunnyvale, California-based company. Such cells could enable Uber to meet its battery energy-density target of at least 300 Wh/kg at the pack level, making its Elevate vision for eVTOL urban air taxis commercially feasible, if other key requirements such as adequate life and high charging and discharging rates can be met.

Amprius’ cells helped enable the initial production Zephyr S stratospheric UAV to stay aloft for almost 26 days in its first flight in July-August. This smashed the record of 14 days set in 2010 by the Zephyr 7 prototype, which used lithium-sulfur batteries. Compared with graphite, silicon has a much higher specific capacity—how much lithium can be packed into the anode per unit mass or volume. “It

Thin silicon “hairs” on the anode (inset) are able to repeatedly swell and shrink without damage during charging and discharging of the cell.
has the highest specific capacity of all the elements and 10 times as much as graphite,” says Bornstein.

In a lithium-ion battery, the ions move from anode to cathode through an electrolyte during discharge and back to the anode during charging. The problem with silicon has been that, when packed with lithium ions during charging, the anode expands significantly—“by several hundred percent,” he says.

“The silicon forms an alloy, and there is a phase change and volume increase,” Bornstein says. “Over a few charge/discharge cycles, that enormous change in volume literally pulverizes the material. There is no cycle life.”

Amprius’ solution has been to develop an anode using silicon nanowires. “This accommodates the swell and allows many hundreds of cycles,” says Bornstein. The anode is made up of thin “hairs” of silicon that can swell and shrink repeatedly without damaging the material.

The cycle life of a rechargeable lithium-ion battery depends on its application and can be 500 for a cellphone, 1,000 for a vehicle or 10,000 for a satellite. “For UAVs, hundreds of cycles is fine, and we can deliver that,” he says. Life can be up to 500 cycles, but that involves a trade-off with energy.

In Airbus’ Zephyr, Amprius’ batteries go through one cycle per day—charging throughout the day and discharging during the night, but at a slow rate. The cell life is enough to give the high-altitude pseudo-satellite (HAPS) its planned flight endurance of “months,” says Bornstein.

Today, developers of urban air mobility eVTOLs “do not have a battery solution, period,” he says. “We are an enabler. Our cell offers a solution, and it’s a much bigger market [than HAPS].” Amprius’ battery “offers high energy and high power with a sufficient number of cycles to be commercially viable.”

Production methods for silicon-nanowire pouch cells are the same as for lithium-ion cells with graphite anodes. The battery management system is also similar but must be tuned to silicon. “Fundamentally, it’s still a lithium-ion battery, with the same safety risk,” says Bornstein. “But it is so energy-dense at the cell level that the challenge is how to prevent a fire if a short circuit releases that energy. So we spend a lot of time on managing the energy and safety because the cells have so much more energy.”

Commercialization is just getting underway, and contracts to supply cells to Airbus for Zephyr will drive the production ramp-up into next year. Amprius is focusing on the aero-space market and high-performance UAVs as it works to build volume. “We are near to flying on something else, but Airbus is the furthest along with the Zephyr,” he says.

Initial cells are “very expensive,” Bornstein admits, but as production volume grows he expects them to be close to cost parity with conventional lithium-ion cells by the mid-2020s, when the urban air mobility market is forecast to take off. “We are engaged in product development for urban air mobility, but the market is not there yet,” he says. “The mid-2020s is perfect for our scaling time line.”

Amprius batteries powered the Airbus Zephyr on its 26-day first flight and have a cycle life that will allow “months” of operation.
In addition to testing technology for future aircraft, the 777F EcoDemonstrator validated new features for the 777X.

Guy Norris Seattle

B uoyed by results of tests of a raft of new technologies on its latest EcoDemonstrator program, Boeing is accelerating the initiative from 2019 onward to underpin development of next-generation aircraft and support improvements to existing products.

Since inaugurating the Eco-Demonstrator series with flights of a specially modified 737-800 in 2012, Boeing has tested 112 new technologies on five aircraft, of which 35 have been transitioned to production programs or in-service use. A further 44 have advanced to higher technology readiness levels and are still at work, while 33 have been discontinued after providing valuable data.

“We have helped accelerate learning,” says Boeing’s director of technology integration and the Eco-Demonstrator program, Jeanne Yu.
“Mike Sinnett, the vice president for product strategy and future airplane development, has asked us to turn up the wick, and we are actually looking at increasing the frequency.” While Boeing is not yet disclosing details of its next series of demonstrator programs for 2019 and beyond, they are expected to represent platforms capable of testing a broader set of technologies, potentially including autonomous and hybrid-electric power systems.

Before the 777F used in the latest EcoDemonstrator program, previous testbeds have been a 737, 757 and 787-8. In addition, an Embraer 175 was used to evaluate a set of airframe and systems advances in conjunction with its Brazilian manufacturer. The 777F, which was leased from FedEx early in 2018, was flown to test 35 technologies ranging from new flight deck systems and alternative fuels and materials to a shorter thrust reverser.

Technologies from earlier Eco-

Tests of a low-weight, low-drag compact thrust reverser could influence the new-midmarket-aircraft nacelle design.

Demonstrator efforts now in service range from the natural laminar flow winglet on the 737 MAX to flight-optimization tools used on most Boeing flights. Touch screens also tested during the program will be incorporated on the 777X, as will a redesigned outflow valve for the aircraft’s upgraded cabin pressurization system, which was validated on the 777F. “Before we flew the touch screens, the 777X program leadership said, ‘Never on my watch.’ But after we flew it, people warmed up to it,” says Yu.

The regular cadence of EcoDemonstrator programs, until now every 12-18 months, has attracted additional technologies for testing beyond those specifically targeted by Boeing. “People now know about the EcoDemonstrator program, and they come to us. It has become almost like a beacon in some way to attract ideas and technologies to look at for the next airplane as well what we can put into the fleet,” explains Yu.

Now, as Boeing faces a potential inflection point in its product development strategy with the growing imperative for even higher-efficiency aircraft using alternative fuels and sources of energy, the program has become more important as a technology proving ground.

“We are at a real critical time right now,” says Yu. “There is more we can do with risk reduction in the next couple of years, and I think that is why we are looking at those opportunities as well.”

Boeing, meanwhile, is completing assessment of the technologies tested on the 777F. They covered innovations in advanced manufacturing, electrical systems, flight deck avionics, flight controls, flight sciences, propulsion and fuels.

“A key first was being able to demonstrate the compact thrust reverser,” notes Yu. For the test, the 777F’s No. 2 General Electric GE90-115B engine was fitted with the new reverser design, which incorporates thermoplastic blocker doors. Developed by Boeing, the concept is designed to help reduce the overall weight and drag of future nacelles and propulsion systems, which continue to grow in size as bypass ratios increase and cores shrink.

The new reverser is designed to help offset potential pressure loss in the duct that, in the case of large engines with very-low-pressure-ratio fans, could have a substantial impact on performance, offering a potential total aircraft performance benefit of 1.5% in fuel savings per seat. Boeing developed the concept, which incorporates a monolithic conic structural design, at its Propulsion South Carolina facility, where the inlet for the 737 MAX is manufactured.

“It was very successful in showing the ability to shorten the nacelle for these very-high-bypass-ratio engines that we may have in the future. We don’t yet know whether that technology will be needed. It will depend on the engine, but at this point we have the technology ready, and we have it bookshelved for whenever it is needed,” says Yu. However, she notes that “some of the integration we learned can be applied to the NMA [new mid-market airplane] in regard to tightening up the installation and helping shorten the nacelle. But we won’t see the compact thrust reverser in its totality until later airplanes.”

The thermoplastic blocker doors in themselves constituted another milestone for the EcoDemonstrator, representing the first time that compression-molded, chopped-fiber structures have been tested in flight. The material, which improves the acoustic attenuation of doors and nacelles, is being investigated for potential use in the MAX, for control surfaces and fairings.

“We are looking beyond the reverser to whether thermoplastic parts might even be load-bearing,” says Yu. The flights proved the chopped-fiber doors could meet static limit load and ultimate load. “We are looking at thermoplastics on the next EcoDemonstrator and seeing what they might be used for. The good news is we successfully validated those materials and our ability to manufacture them, and we are looking at applications quite aggressively right now.”

EcoDemonstrator program manager Doug Christensen says Boeing will be working with the supply chain to develop aerospace thermoplastics. “It’s about the material specs and making sure it’s producible at a rate to meet our demands,” he notes.

The 777F program registered another key achievement: It was the...
first time a large commercial transport was flown using 100% paraffinic biofuel. “It worked great. We did the 100% biofuel flight for a demo day with FedEx, because they have a goal of operating with 80% alternative fuel by 2030 as part of their corporate mission,” says Yu.

The alternative fuel offers several potential benefits including 3-4% lower specific fuel consumption, improved engine maintenance, lower smoke levels and up to an 80% reduction in life-cycle greenhouse gas emissions. “Today, the ASTM [American Society for Testing and Materials] specification is limited to a 50-50 blend, and we are trying to push the boundaries to 100%. If it meets all the specs, do we need that limitation? We are taking that data as well as other flight tests on other vehicles, including military aircraft, to try influence the certification to allow more use of biofuels,” explains Yu.

Intriguingly, the flight tests indicated the biofuel also had a higher energy density than standard jet fuel. The pilots “had to pull back on the throttle when they switched over the tank to the biofuel,” she says.

“We would load up the tanks to full volumetric shutoff, and the tank with the biofuel would actually indicate a lighter weight,” points out Kirk Vining, the Boeing engineering test pilot for the EcoDemonstrator program. “By volume, the aircraft was carrying the same energy density, but the actual fuel flow per pounds was lower.”

Testing also included evaluation of a tracking, locating and data recovery (TLDR) system developed by Flyht Aerospace Solutions of Calgary, Alberta, in the wake of the disappearance of Malaysia Airlines Flight 370 in 2014. The system takes key information from the flight data and cockpit voice recorders as well as an internal GPS receiver and inertial system and live-streams it to the ground via the Iridium satellite network. “If the aircraft deviates in a significant way from its predicted track and altitude then the TLDR wakes up and starts sending down data at a more rigorous pace. Normally, it just sits there and records and sends down on an infrequent basis. But if something triggers it into thinking something is not right, it starts sending all the data down,” says Christensen.

Aimed at supporting the international goal of developing by 2021 regulations and standards for a global autonomous distress tracker system and the timely recovery of flight data, the TLDR eliminates the need for automatically deployable flight recorders. “The purpose of the flight test was to evaluate the equipment and prepare for a white paper and the standards we will have to go through. We also worked with Embraer on that technology, and we are trying to develop an industry solution for tracking and locating aircraft in flight. This was a powerful way to bring together the OEM and suppliers to develop an industry standard,” Christensen adds.

Boeing also is analyzing data from tests of the surface operations collision awareness system (SOCAS), which used optical and radar sensors to detect aircraft, vehicles, buildings and other ground obstacles. Targeted at reducing costly ground-collision incidents on increasingly congested ramps, the system tracks obstacles and uses machine vision (imaging-based automatic inspection and analysis) to determine distance and time to collision. An aural alert is issued to the crew if a potential collision is detected.

Ground tests conducted at Glasgow, Montana, verified that stationary and moving objects could be detected and crews warned in a timely manner. A radar system was mounted in the wing leading edge while the camera was mounted in the leading edge of the tail fin. “We are continuing to develop that capability in the pipeline for the next demonstrators,” says Christensen. The camera position is similar to that of the tail-mounted system offered for ground maneuvering. “But the capability and sensitivity are different, so potentially they could be incorporated together. However, the team is still trying to figure out the right location for the camera sensors themselves. The ideal system will probably be a combination of both radar and camera. There are benefits and needs for both, and SOCAS would be paid for by avoiding one AOG [aircraft-on-the-ground] incident,” he adds.

Another system that produced promising results was an advanced Doppler Lidar clear-air turbulence detector developed by JAXA, the Japan Aerospace Exploration Agency. The laser-based system receives scattered light reflected by suspended aerosol particles such as water drops and dust. A processor analyzes variation in light wavelength caused by the Doppler effect to determine airflow motion ahead of the aircraft. Variations in these wavelengths therefore make it possible to detect clear-air turbulence, which conventional weather radars fail to identify.

Although similar technologies have been developed and tested in the past, the resulting Lidar systems often have proved too large and heavy for practical use. This is partly because a more powerful laser is required to detect
backscatter from the lower density of aerosols at high altitudes over 10 km, at which passenger aircraft typically cruise. The Lidar under test on the 777F was a lighter, more compact version of a 1-Hz twin-laser system JAXA developed in 2011.

“JAXA is excited because the system performed as expected, and it was the first time they had flown the system on a commercial aircraft at the speeds and altitudes that we fly at,” says Christensen. Testing took place in different air masses over land and coast. “We got a lot of data, and they were able to validate the 10-km-plus range of the system and got good mapping of that performance at altitudes ranging from 2,000 to 40,000 ft. and at different speeds. We are talking to them about the next steps, including making it smaller to fit in the aircraft and improve the display.”

Other highlighted experimental payloads include a fitting made from recycled titanium on the aft fairing heat shield mounted above the engine exhaust duct. Known as Ti64Mod, the low-cost alloy has around 75% recycled content and has been developed to reduce waste and cost in partnership with Embraer as well as providers in Russia.

“The Russian partners have the capability and the facilities to recycle, and with Embraer we are working to develop specifications and qualification testing to make sure the material meets requirements,” says Yu. Embraer is conducting microscopic inspections for cracks or flaws to compare the fitting with a conventional milled part. “Because of what we did, it is now an option on the 787 program,” notes Christensen.

The EcoDemonstrator also tested a high-definition camera-based visual detect-and-advise system, developed with Boeing Australia and designed to provide a machine-equivalent “see-and-avoid” capability for cockpit crews against unmanned aircraft and other non-cooperative targets. The system, in which the sensor is mounted on the glareshield, was tested against simulated incursions using the company’s Lockheed T-33 chase plane over Montana. Test results were promising, and a next-generation system is planned for evaluation in 2019.

A related safety system also tested on the 777F was the Aircraft Collision Avoidance System for NextGen (ACAS X), the anticipated future replacement for the traffic-alert and collision-avoidance (TCAS) system used since 1993. The FAA plans to replace the TCAS to allow use of automatic dependent surveillance-broadcast (ADS-B) and to provide collision-avoidance protection during NextGen procedures with reduced separation, such as closely spaced parallel operations. It also will be required to protect against collisions with unmanned aircraft.

ACAS X uses transponder interrogations as well as ADS-B signals to detect and track nearby aircraft and will use the same antenna and displays as the current TCAS II system. However, unlike TCAS II technology, which uses rule-based logic to model a spectrum of pilot responses, ACAS X’s alerting logic uses probabilistic models to represent various sources of uncertainty. These modes rely on computer-optimized logic lookup tables that capture each possible state in the probabilistic state distribution. “The RTCA standards organization right now is looking at data to get approval to replace TCAS, and we are working with them to get that on an ACAS X into service,” says Christensen.

The EcoDemonstrator also played a key role in validating Boeing’s synthetic instrument landing system (SILS), which is being developed as a retrofit option to allow suitably equipped aircraft to fly GPS-based precision approaches. In particular, SILS is designed to enable GPS/Ground-Based Augmentation System landing system approaches as well as localizer performance with vertical guidance. The 777F demonstrated compatibility of the system, which uses a multi-mode receiver, with the 777F systems architecture. Certification tests are scheduled for later in 2019.

Other technologies tested included a more efficient variable-frequency generator developed by Safran, NASA-printed carbon nanotube sensors for continuous health and load monitoring, additively manufactured titanium parts, and a Lidar-based air data sensor. Also evaluated were a pilot-worn device to monitor real-time alertness, a boundary layer measurement sensor to calibrate computational fluid dynamics methods for after-body designs on future aircraft and updated digital tools for improved flight planning, routing and fuel use.
As control of the U.S. House of Representatives shifted to the Democrats, Rep. Rick Larsen (D-Wash.) became chairman of the House Transportation Committee’s subcommittee on aviation, which has jurisdiction over all aspects of civil aviation, including safety, infrastructure, labor, commerce and international issues. Larsen outlined his views and priorities for 2019 in a recent interview with Aviation Week’s Ben Goldstein.

What do you view as the proper role for Congress in scrutinizing airline business practices? The first priority of the FAA—and this committee—should be to ensure safety. So the focus will be on overseeing how the FAA is implementing provisions that we put into law on consumer safety. I think that’s where pitch and seat size really come into play. As the footprint inside the cabin changes, you can’t have seats so small and pitch so narrow that passengers can’t evacuate an airplane in a reasonable amount of time. I think we need to be careful about jumping into the fee debate. I fly a lot so I get that people are frustrated, but fees are a way for airlines to manage loads and consumer behavior. We just want to ensure that the airlines aren’t taking advantage of consumers as they are doing that.

A perennial complaint from airports is that the Passenger Facility Charge (PFC) cap of $4.50 per flight segment has remained unchanged over the past 17 years. You can’t have a big-league economy with little-league infrastructure, and there’s currently about a $10 billion annual shortfall in unmet capital needs for U.S. airports. If we’re going to maintain competitiveness in the global marketplace, we have to address the funding needs of airports around the country. The willingness of Congress comes down to whether people see the PFC as a tax increase or a mechanism to invest in airports. I think airlines make a reasonable case that they don’t want the price of tickets being even higher, but without this investment, the competitiveness of airports and our economy will degrade over the long term.

Would you support examining a reduction in the 1,500-hr. minimum flight rule for first officers? No, I don’t support exemptions or softening that requirement. The market is the solution for the pilot shortage and [airlines’] ability to attract qualified pilots. And beyond pilots, we’re also facing shortages of maintenance and technical workers. We included a provision in the FAA [reauthorization] to develop a task force to look at worker shortages in aerospace and aviation, and a key focus of this committee in 2019 will be to make sure the FAA is getting that task force up and running.

Do you feel the FAA’s NextGen air traffic control modernization effort is making adequate progress? I don’t think it is being deployed fast enough. The airlines haven’t seen enough return on it, and I understand their frustration. But ultimately the future of airline travel is embedded in some of these basic technologies that we give this broad name of NextGen. I want to be sure we prioritize which technologies are the most important and do our best to try and prevent others from making everything a priority, which only slows down the deployment of the top priorities. One of the first trips I want to take with subcommittee members is to the FAA technical center in Atlantic City, New Jersey, so we can talk with the FAA engineers and contractors and see some of the work they have been doing. Without that knowledge base, it’s easy to get bogged down in the debate about whether NextGen is being deployed fast enough or not.

As Democrats take control of the House, do you think a bipartisan infrastructure deal is possible? Putting an infrastructure package together with the Trump administration is an area where Democrats and the White House can work together early on. I think an infrastructure package needs to include aviation, not just roads and bridges. If the economists are correct in saying the economy is going to slow down and we’ve come off the sugar high from the tax cut, then an infrastructure investment package is a good way to keep the economy moving. Washington, my home state, passed gasoline taxes. You have a low unemployment rate and men and women working on building roads, bridges, highways and transit systems to keep our economy moving. There’s a good lesson there for Congress.
The FAA and Defense Department have agreed on a framework for accommodating military aircraft once the FAA’s requirement that operators equip for automatic dependent surveillance-broadcast (ADS-B) “Out” position reporting becomes effective in January 2020. Some military aircraft may not be outfitted until 2029, and a limited number never may be equipped, the Pentagon says.

The two agencies concluded a memorandum of agreement (MOA) without fanfare last summer to guide their joint efforts toward ADS-B implementation. Acting FAA Administrator Dan Elwell signed the agreement on June 26; Air Force Secretary Heather Wilson signed it July 17.

The MOA “establishes a broad framework of follow-on actions and milestones necessary to accommodate Defense Department aircraft for their national security and defense mission requirements,” an Air Force official stated.

The agencies “are jointly pursuing a post-2020 accommodation strategy that assures the Defense Department the same level of access to the national airspace system that it continues to have prior to the mandate,” the statement adds. “The accommodations will address those Defense Department aircraft that will not be equipped with ADS-B Out by 2020 as well as certain national security mission sets conducted by aircraft that are ADS-B Out equipped.”

Flights in most U.S.-controlled airspace will require that aircraft be equipped with a Version 2 ADS-B Out system as of 2020. Aircraft flying above 18,000 ft. or internationally must have a GPS position source and Mode S Extended Squitter (1090ES) transponder to regularly broadcast their position to air traffic control (ATC). Operators of lower-flying aircraft in domestic airspace have the option of installing GPS and a 978 MHz universal access transceiver.

The FAA’s final ADS-B regulation, published in May 2010, says “no special allowance is made in this rule to relieve the military from the same performance requirements as the civilian aviation community.” But it notes that military and federal aircraft not so equipped can obtain an “ATC-authorized deviation” to operate in airspace where ADS-B is required. Separately, the agency says it “has always envisioned” an agreement with the Pentagon to accommodate non-complying military aircraft.

The Defense Department operates 13,000 manned aircraft across three services. At its last full meeting in June 2018, the FAA’s

The Navy Air Systems Command has ordered ADS-B kits for T-6 Texan II turboprop trainers like this one at NAS Christi, Texas.

The statement adds: “There may be some limited number of aircraft which may never be equipped due to operational security risks or due to imminent retirement. In some cases, cost, budget and depot schedule constraints make it prohibitive for the Defense Department to equip all [military] aircraft by the compliance date. Initial projections indicate Defense Department compliance, for those aircraft that will equip, should be complete by 2029.”

The Air Force allocated $250 million in its fiscal 2019 budget to equip 20 aircraft types for ADS-B Out, including older-model F-16C/D Block 25/30/32 fighters, the A-10 Thunderbolt II close-air-support jet, C-17 Globemaster III cargo jet, KC-10 Extender tanker, T-6 turboprop trainer, T-38 Talon jet trainer and C-21 (Learjet 35A) transport. New Boeing KC-46 Pegasus tankers will come ADS-B-equipped.

The Army, which reports operating about 3,700 helicopters and 250 fixed-wing aircraft, has an overall goal of a fully ADS-B-compliant fleet but acknowledges that a portion of both fleet types will not be equipped by the 2020 mandate.

Last August, the Naval Air Warfare Center Training Systems Division announced its intention to award Boeing an order for ADS-B Out kits to equip Navy T-45C Goshawk jet trainers over four years. In October 2017, the Naval Air Systems Command awarded Textron Aviation an $8 million contract modification to supply ADS-B kits for 251 Navy and four Army T-6 Texan II turboprops.

A U.S. Government Accountability Office (GAO) official says the MOA is a “necessary step” toward addressing security risks associated with equipping for ADS-B as well as those associated with divesting secondary surveillance radars—issues the GAO flagged in a January 2018 report to Congress. The agency recommended that the secretaries of Defense and Transportation incorporate mitigations in the agreement to reduce operational, aircraft and personnel security risks, plus cyber and electronic warfare vulnerabilities of the technology.

“The MOA does not describe actual security measures or solutions that address ADS-B Out-related security risks. It does provide for agreement between FAA and the Defense Department that such solutions will be further explored, tested, and implemented, if appropriate,” says Joseph Kirschbaum, the GAO’s director of defense capabilities and management. ©

—With Henry Canaday in Washington
Concern over a future pilot shortage is bringing airlines and major training and simulation providers closer together and driving business in the training sector. New training partnerships, facility expansions and simulator sales in the last year signal an industry ramp-up to produce pilots.

Canada’s CAE reports an “unprecedented demand for professional pilots and a new urgency to develop better pilots faster.” It estimates there will be a population of more than 500,000 airline and business jet pilots by 2028, of which 300,000 will be new pilots.

Last year, CAE launched four new cadet training programs—with American Airlines, Aeromexico, AirAsia and Vueling—renewed two others and continued four programs dating to 2016-17. Over the past 18 months, it concluded 40 long-term pilot training agreements with airlines.

“Increased pilot demand is motivating fleet operators and training providers like CAE to work more closely together,” says Nick Leontidis, CAE group president for civil aviation training solutions. “Smarter pilot creation that helps cadets flourish earlier and improves the likelihood of success throughout a pilot’s career is a joint aspiration and mutual goal.”

In second-quarter fiscal 2019 results announced in mid-November, CAE reported C$393 million ($299 million) in revenue from its Civil Aviation Training Solutions business, up 24% from the same previous-year quarter. It signed training contracts valued at C$573 million and sold 16 full-flight simulators (FFS) built at its Montreal manufacturing site, bringing simulator sales to 34 for the first half of the year. Its civil business backlog was a record $4.3 billion.

Acquiring Bombardier’s business aircraft training unit for $645 million, a purchase announced Nov. 8, 2018, and expected to close in the second quarter of 2019, will increase the company’s recurring and wet-training revenue and expand its access to the training market for customers operating 4,800 in-service Bombardier business jets. The agreement comes with 12 installed or soon-to-be deployed business jet FFS.

CAE has deployed 264 multimillion-dollar FFS across its civil training network and to joint-venture training centers and third-party customers. Of the 250 within its network, 60% are devices used for commercial aviation training and 40% for business aviation and helicopter training, the company says. It deployed 12 FFS last year—10 for airline training—including its latest CAE7000XR series Level D FFS equipped with Tropos 6000XR visual image generators.

New York-based L3 Technologies entered the civil aviation training segment with its 2012 acquisition of Thales Training and Simulation, in Crawley, England. From around four FFS produced there annually, L3 says it now builds 30 or more RealitySeven Level D simulators. Since the acquisition, L3 has deployed 18 of its RealitySeven simulators.

The CAE5000 series full-flight simulator is used in training for commercial narrowbody airliners.

> **AIRCRAFT TRAINING PARTNERSHIP FORMED**

> **ROBUST GROWTH REPORTED AT CAE**

> **NEW AIRLINE AND TRAINING PARTNER FORMS joint-venture**

> **L3 TO OPEN NEW LONDON TRAINING CENTER**

> **SIMULATORS BUILT TO NEW FAA REQUIREMENTS**

Bill Carey Washington
Ramp-Up

In July, the parent company announced the combination of its avionics, airport security and pilot training units into L3 Commercial Aviation. This was followed in October by the official opening of an expanded multipurpose training center in Arlington, Texas, for fixed-wing, helicopter and unmanned aircraft systems pilots. The 40,000-ft.² expansion doubles the size of the training center near Dallas-Fort Worth International Airport, adding room for six additional FFS, classrooms and other space.

L3 has invested $100 million in a new London Training Center near Gatwick Airport, scheduled to officially open in the first quarter. The company is consolidating multiple facilities in the Crawley area into a 150,000-ft.² training and manufacturing facility that will accommodate eight FFS, four high-fidelity flight training devices, eight flat-panel trainers and classrooms, as well as simulator manufacturing bays.

EasyJet, Iceland’s WOW Air, Norwegian and charter carrier TUI Airways are among the airlines that have committed to using the center, which also will support L3’s cadet training programs.

In the half-year after the company launched L3 Commercial Aviation, it announced pilot training agreements with Air France and TAP Air Portugal in Europe, Qantas at Toowoomba Wellcamp Airport in Queensland, Australia, and Icelandair. The latter calls for training 60 pilots over three years, with Icelandair covering 100% of the course costs.

“Now we have much more interest from the major airlines domestically and internationally. They are doing everything they can to secure longer-term contracts for a very regular feed of pilots,” says Todd Gautier, L3 Technologies, electronic systems segment president.

“Instead of just agreeing to provide future jobs for these pilots, we are seeing in many places that they are actually investing in these pilots and willing to sponsor them, sometimes by covering the cost of the training,” Gautier says.

“What a lot of the airlines are willing to do to ensure a steady stream of pilots going forward has evolved significantly in just the last 12 months, and we are going to see that continuing, I believe.”

L3 has announced recent contracts to supply training devices to several airlines, including four Chinese carriers. The company in November announced its first order from China’s Loong Air to deliver three Airbus A320 FFS and two flat-panel trainers for installation at Hangzhou within the next three years.

In July, L3 announced contracts with Shenzhen Airlines to provide a Boeing 737-8 RealitySeven FFS in 2020 and with China Southern Airlines to provide two Airbus A320 and two Boeing 737 FFS within a year for its training centers in Zhuhai. Qingdao Airlines selected L3 to provide two A320 FFS and two flat-panel trainers for installation in 2019-20 in Longkou.

Other contracts were signed with Air France for an Airbus A350 FFS and Qantas for a Boeing 787-9 FFS. Over recent history, about 75% of FFS have been delivered to airlines and 25% to training centers, the company says.
Business aircraft and regional airline training are core markets for New York-based FlightSafety International, representing 60-70% of annual gross revenue of the company’s commercial training operations, executives say. The balance is split among government training services and manufacturing operations.

FlightSafety designs and builds the FS1000 Level D FFS at a 375,000-ft.² facility in Broken Arrow, Oklahoma. Another plant in St. Louis supplies the simulator’s VITAL 1100 visual system; a subordinate facility supplies rigid glass mirrors for the visual system.

The company builds simulators for aircraft types from major manufacturers and has been negotiating with a customer to supply its first Airbus A220 simulator, according to executives.

FlightSafety’s newest flight training facility was officially opened in Denver in late 2016. The Denver Learning Center trains SkyWest Airlines pilots, supported by one Bombardier CRJ200, one CRJ700 and three Embraer 170 simulators. The facility also trains helicopter pilots for air medical services provider Air Methods in a separate wing, supported by Level D simulators for the Bell 407 and Airbus Helicopters H125, H130 and H135 rotary-wing aircraft.

The company says 500 students have been undergoing primary flight training at its ab initio academy at Vero Beach Regional Airport, Florida, where it has programmed a “pathway” method for pilots to land jobs with airlines. Last July, Delta Air Lines named the FlightSafety Academy and ATP Flight School as training providers for its Propel Pilot Career Path program to help recruit and train the 8,000 pilots it expects to hire in the next decade.

“We’ve got packages today for students to come in at different levels, whether they’re just starting, whether they’re private or commercial or instrument-rated, and we will work with them to get their additional ratings,” says Steve Gross, FlightSafety senior vice president for commercial. “You have to get 1,500 [flight] hours to be employable today. We will put you into the instructor pool and have you do training.”

FlightSafety provides an airline transport pilot (ATP) certification training program that prepares candidates and other platforms at various U.S. locations.

In addition to helping airlines recruit and develop new pilots, training providers say simulators enhanced with new technologies and approaches—augmented reality, mixed reality, data analytics, artificial intelligence—can move students more efficiently and at lower cost through the training pipeline.

At an FAA-sponsored aviation workforce symposium last September, Roger Sharp, representing Redbird Flight Simulations of Austin, Texas, argued that simulator technology is evolving faster than the regulations that govern it. Already, he said, FAA Part 141 flight schools have the flexibility to incorporate training devices with new capabilities in their courses.

Under Part 141.57, “Special curricula,” a flight school “may apply for approval to conduct a special course of airmen training . . . if the applicant shows that the training course contains features that could achieve a level of pilot proficiency equivalent to that achieved by a [pre-

FlightSafety International builds simulators for major-manufacturer aircraft types such as the CRJ700.

who already have a commercial pilot certificate with instrument and multiengine ratings to take the FAA’s ATP written exam. The program’s ground training segment bridges the gap between a commercial pilot’s knowledge level and what is expected of an ATP certificate holder, focusing on aerodynamics, automation, adverse weather conditions, turbine engines and transport-category aircraft performance. Simulator training takes place on CRJ, Embraer 145 and 170, ATR 72, Bombardier Q400
scribed] training course,” the regulation states.

“Part 141 providers can put together whatever concept of technology and training programs they would like right now, and [if approved] it can be done tomorrow,” says Sharp. “This is the place where advanced technology can be at its best.

“I think the FAA needs to start with a clean-sheet approach to this and allow industry in and talk about what we’re trying to do with [a] particular device,” Sharp adds.

“If we do so, we can create a device that is far better than a current Level D simulator at a fraction of the cost.”

Scott Goodwin, vice president of simulation with FlightSafety, says simulator manufacturers are exploring technologies that would help speed students through the training regimen.

“You really get two options,” he says. “You either try to increase the size of the pilot pipeline [by] growing capacity—more centers, more simulators—or you try to increase the velocity through the pipe, to shorten the training time.

L3 Technologies sector President Leonard Genna (center) cut the ribbon on a facility expansion in Arlington, Texas, in October, flanked by Arlington Mayor Jeff Williams (right) and builder Craig Morris, senior vice president at Cadence McShane.

“That’s something that everybody is looking at right now,” says Goodwin. “What are the new technologies that can be applied in different ways that accelerate the training process? You still have the experience requirement of 1,500 [flight] hours, but can you get them through a six-week course in four weeks instead?”

Gautier says L3 is looking into training optimization that more closely aligns with the proficiency levels of different individuals. More effective training using various media, including devices with lower fidelity than full-motion simulators, can save airlines money, he explains.

“The current modus operandi is to train to the least common denominator,” says Gautier. “If you could create a dynamic, optimized training curriculum that allows you to train and promote forward individuals as they demonstrate the proficiency in certain tasks and capabilities, you’d be able to much more effectively train an individual and dramatically reduce the cost of training overall from an enterprise perspective.

“Many of the airlines we’re talking to are extremely excited about the economic benefits of creating [an] individualized training curriculum so that people are trained in an optimal manner, which would reduce the training time across an enterprise,” Gautier adds. “There’s no sense flying somebody three times in something once they’ve already mastered that skill or task.”

In March 2016, the FAA issued new standards for extended envelope and adverse weather training of airline pilots on full-flight simulators under its Part 60 Change 2 regulation. As of March 2019, simulators must support five additional training tasks: recognition of and recovery from a full stall; upset prevention and recovery; engine and airframe icing; takeoff and landing with gusting crosswinds; and recovery from a bounced landing. Directive 2 of the rule requires that previously qualified simulators be modified.

Simulator manufacturers are rolling out newly capable devices. “In almost every single case, it requires a modification to the existing software because the flight models on the simulators don’t include the necessary data to model particular regimes of flight,” says Goodwin. “Every new simulator that we deliver out of a facility, basically for about the last year, is compliant with those new requirements. We are in the process of going back and doing all of the upgrades to all the existing fleet. That is progressing on schedule.”

CAE says it has qualified Boeing simulator types for extended envelope and adverse weather training and in April qualified the first 7000XR series Level D simulator for the A320.
By order, dated December 21, 2018 (ECF No. 159) (the ‘Bidding Procedures Order’), the Bankruptcy Court for the Southern District of New York (the ‘Bankruptcy Court’) approved bidding procedures (the ‘Bidding Procedures’) that govern the sale of the Purchased Assets to the highest or best bidder.

The Debtors have requested the Bankruptcy Court enter one or more orders (i) pursuant to a motion, dated December 10, 2018 (ECF No. 64) (the ‘Motion’), Macquarie Real Estate Leasing Holdings Ltd. (as set forth in a certain asset purchase agreement (the ‘Macquarie APA’)), which provides, among other things, for the sale of the Purchased Assets, (ii) the Sale Order, the Sale Transaction, or the assertion by such person or entity of any objection to the Motion, the Sale Order, the Sale Transaction, or the assumption by one or more successful bidders of certain liabilities. A separate notice will be provided to counterparties to executory contracts and unexpired leases with the Debtors that may be assumed and assigned.

The failure to abide by the procedures and deadlines set forth in the Bidding Procedures Order and the Bidding Procedures may result in the denial of your Third Party Bid or Credit Bid.

Any interested bidder should contact the Debtors’ advisors:

Miguel Ornelas; Tel: 661-480-7000 • miguel.ornelas@aviationweek.com

Non-Compliance of any person or entity to file and serve an objection to the Motion, the Sale Order, the Sale Transaction, or the assertion by such person or entity of any objection to the Motion, the Sale Order, the Sale Transaction, or the assumption by one or more successful bidders of certain liabilities shall be a bar to the assertion by such person or entity of any objection to the Motion, the Sale Order, the Sale Transaction, or the assumption by one or more successful bidders of certain liabilities.

A list of the Debtors in these Chapter 11 Cases, along with the last four digits of each Debtor’s federal tax identification number, is attached to the Motion as Exhibit A.
The Debtors have requested the Bankruptcy Court enter one or more orders collectively, the "debtors and debtors in possession in the above-captioned chapter 11 cases (collectively, the "Debtors") are seeking to sell all or substantially all of their assets assumed and assigned. Debtors' assets free and clear of liens, claims, encumbrances, and other interests, including any amount received by the Debtors during the pendency of the bankruptcy case (collectively, the "Debtors' Assets").

The Auction may be held at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court.

The Auction on January 8, 2019 at 10:00 a.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

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The Auction on January 7, 2019 at 5:00 p.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction on January 14, 2019 at 5:00 p.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction on February 12, 2019 at 10:00 a.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction on February 14, 2019 at 10:00 a.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction on February 19, 2019 at 10:00 a.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

The Auction on February 26, 2019 at 10:00 a.m. (ET) at the Premises or via online bidding, which is being conducted through a publicly accessible online bidding platform (the "Auction Platform"). The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.

Objections must be filed and served in accordance with the Bidding Procedures Order and (to the extent required) the Macquarie APA. Any person or entity desiring to file an objection to the sale must do so, or notice thereof, at least two business days prior to the Auction or at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court, or (iii) the expiration of any adjournment of the Sale Hearing. The Auction may be adjourned without notice or with limited and shortened notice to parties, including by (i) an announcement of such adjournment at the Sale Hearing or (ii) the filing of a notice of adjournment with the Court. The Auction may be conducted via electronic means, including by telephone, video conference, and/or the Auction Platform.
Wanted: A Hypersonics Workforce

By Brian M. Argrow

“Boost-glide,” the method of using rocket propulsion to achieve high speed before an unpowered glide, is an apt metaphor for U.S. investment in hypersonics research and education. Recent interviews with government leaders and experts suggest that the U.S. no longer has the luxury of exploring hypersonic flight as an unchallenged leader. In addition to the need for long-term commitment to basic research and technology development, there is a more urgent requirement for rapid deployment of countermeasures against putative adversarial capabilities.

In early 2018, following claims by President Vladimir Putin of Russian advances in hypersonic missile technology, Pentagon leaders including Undersecretary of Defense for Research and Engineering Michael Griffin and DARPA Director Steven Walker responded with warnings about the state of U.S. hypersonic capabilities. They emphasized that hypersonics must be a priority for Defense Department research and that, even with Trump administration requests for increased funding, there is still a need for more spending, particularly on infrastructure to support testing.

The challenges of hypersonic flight are not new. Many of today’s educators and decision makers were inspired by U.S. high-speed research including the X-15 hypersonic program that ended in 1968 after 199 flights. Using a boost-glide flight profile, the X-15—the first hypersonic crewed aircraft—set a record of Mach 6.7 (4,520 mph) in 1967. It was also the first reusable spacecraft, setting the altitude record of 354,000 ft. (67 mi.) and earning pilot Joseph Walker astronaut wings.

Since the retirement of the X-15, other X-plane programs have focused on the development of hypersonic technology that only recently culminated in flight tests. These programs include the X-30 National Aero-Space Plane and the X-33 that did not lead to flight-test vehicles, as well as the more recent, more modest X-43A Hyper-X and X-51A Wave-rider programs, which demonstrated air-breathing hypersonic flight in 2004 and 2010.

A hypersonic “aero-space plane” is the ultimate multidisciplinary aerospace engineering system. Every traditional discipline, such as fluid dynamics and heat transfer; and more recent disciplines, such as software engineering and cyberphysical security, must be integrated.

In the June 2018 issue of Aerospace America, University of Michigan professor Iain Boyd points out that 60-70% of U.S. research is focused on aerodynamics and aerothermodynamics, whereas the Chinese are pursuing a more balanced multidisciplinary effort spread across aerodynamics, propulsion, materials and controls.

As the foundation of our innovation workforce, most U.S. Ph.D. candidates are supported either directly or indirectly by external research grants. Yet even if the aforementioned budget requests go through, they’ll be going toward programs that don’t address the breadth of potential hypersonics applications and are not structured in a way that will help grow our hypersonics industrial base.

If the U.S. is to retain (or reclaim) leadership in hypersonics, a sustained increase in university research programs to support students—and new research infrastructure—is critical. This does not imply that all increased funding should be directed solely to universities, but research programs that support joint agency-university research are proven vehicles for leveraging federal funding. Similar industry-sponsored programs also have a proven return-on-investment track record.

Ideally, this increased support should happen at both ends of the spectrum: supporting university-led research by faculty and students and providing faculty and students access to higher-end, larger-scale federal agency-led research by increasing development of test facilities and the design-build-fly cadence of flight-test vehicles and other agency testbed programs. As a safeguard for American leadership, the government should ensure a minimum amount of activity to support low-cost and efficient university-led research.

Educators are witnessing an explosion of excitement among engineering students spurred by new technologies and opportunities in areas such as robotics and autonomous systems and a full-blown commercial space race. Student enrollment in the University of Colorado Boulder’s Ann and H.J. Smead Department of Aerospace Engineering Sciences has more than doubled over the past decade, and demand continues to grow. Young men and women in such departments across the nation will lead the hypersonics research of the future and create new businesses enabled by this emerging technology—if we let them. This future requires a national endeavor of grander scope than the narrowly focused, boost-glide approach we have seen so far.

Brian M. Argrow is professor and chair at the University of Colorado Boulder’s Ann and H.J. Smead Department of Aerospace Engineering Sciences.
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