The Spaceship Co.  
Powering Virgin to Suborbit

Narrowbody Update  
New models, more output, rising competition

Flight Decks of the Future 
Airbus-Dassault Fighter Alliance

Aviation Week Workforce Initiative  
Supported by: The Wings Club
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Virgin Galactic’s Unity, the first SpaceshipTwo to be built and powered by The Spaceship Co., accelerates toward an apogee of more than 84,200 ft. with seconds to go before its hybrid rocket motor shuts down. Our reports on Virgin Galactic and The Spaceship Co. by Los Angeles Bureau Chief Guy Norris and on sister company Virgin Orbit by Senior Space Editor Irene Klotz begin on page 32. The Spaceship Co./Virgin Galactic photo. Aviation Week publishes a digital edition every week. Read it at AviationWeek.com/awst.
Hainan lands the first Split Scimitar® Winglets in China.

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FEEDBACK

“IT APPEARS THAT THE MQ-25 PROGRAM IS PUTTING ALL OF OUR U.S. NAVY ‘FLYING EGGS’ INTO ONE U.S. AIR FORCE BASKET”

– WILLIAM CHAO
commenting about “MQ-25 Decision Time” (April 9-22, pp. 56-63)

MQ-25 OVERKILL?
Your “MQ-25 Decision Time” cover story (April 9-22, pp. 56-63) was a thorough overview of the MQ-25 competition, but it left one key concern unexamined.

Given that one of the primary purposes of aircraft carriers is to project power in places where other branches of the military find it difficult to do so, exactly how will U.S. Air Force refuelers be able to service any U.S. Navy aircraft when there are no accessible air bases nearby from which to launch their tanker aircraft?

One of the major tenets of battle when a shooting war starts is to crater enemy air base runways to prevent any aircraft from being able to take off, so how will these grounded Air Force tankers be able to service any naval aircraft?

It appears that this program is putting all of our Navy’s “flying eggs” into one proverbial Air Force “basket.”

William Chao, Milpitas, California

ONLINE, commenters noted other aspects of this topic.

myke.predko wonders:
What the price is for a land-based version of the aircraft. If it was inexpensive enough, I could see it as an alternative to C-130 and Airbus A320 derivatives used by various air forces—Canada comes to mind.

arizonan, on another note, says:
Just as automation is able to replace the pilot, automation will be able to replace the boom operator. Automation is capable of much more precision than a human, eliminating damage to stealth coatings. A version to refuel U.S. Air Force airplanes would be useful.

SlowMan asks how:
Lockheed’s nonexistent type can compete against rivals whose prototypes are flying.

WE’RE LATE TO NEED . . . AGAIN
Juxtaposing two articles related to drones and the urgent need to defend against them, “U.S. Army Rediscovers Importance of Air Defense” and “Military Tackles the Problem and the Potential of Drones” (April 23-May 6, pp. 38 and 44), respectively, raises troubling questions about U.S. defense planning. Clearly, the Army’s ill-advised decision to abandon the concept of short-range air defense now places us in a dangerous catch-up race with an extant and rapidly evolving threat.

The Russians are much more advanced in this regard, and essentially can tweak their existing Pantsir system to come up with a viable solution. In fact, Pantsir has been in service since 2012 and by now is combat-tested and on order with several countries. The U.S. will be lucky to have any such capability fielded by 2025.

Assuming that U.S. Air Force top cover pretty much guaranteed protection for our ground troops against enemy air attack apparently blinded us to low-tech, low-level threats. Russia’s tradition of providing dense, multilevel air defense in depth for its troops, which began in the Soviet era, is now paying dividends. We should have seen this coming, especially as Russia was fielding the Pantsir; it might have paid dividends for us as well.

Ralph Clem, Jacksonville, Florida

FAULTY FOCUS
Regarding the in-flight failure of the CFM56 engine on a Southwest Airlines Boeing 737-700 that led to the death of a passenger on April 17 “Southwest Engine Failure Ripples.” (April 23-May 6, p. 27), it seems that Aviation Week, the FAA and the NTSB have their “immediate focus” on the N1 fan blade failure.

Your immediate focus should be on the fact that the investigator in the photograph walked right up to the N1 blades and did not hit his legs on the lower lip of the engine nacelle. Engines fail, we know this and manufacturers test this. Fan blades fail, we know this and manufacturers test this as well. Because we know these events will happen, existing requirements state that during certification the engine must demonstrate that it will contain a blade-off event. This is the insurance policy to protect the airframe, aircraft systems and, most important, the passengers and crew from catastrophic engine failures.

The immediate focus should be on why this containment structure and the nacelle are failing, not why the N1 blades are coming apart. Blade failure would have been a nonevent if the nacelle and N1 containment structure had performed as designed.

James Hamann, Broomfield, Colorado

ONLINE, containment design was discussed as well.

SeeTepees says:
I suspect there is a good chance the investigation will find the engine contained the liberated fan blade as it was certified to do. I’m concerned with the nose and fan cowl failures as a result of the severe engine vibration due to fan rotor imbalance caused by the missing blade. It will be interesting to see if the NTSB investigation finds any repairs to the inlet nose cowl that may have compromised its ability to meet the expected vibration loads caused by a blade-out event.

Address letters to the Editor-in-Chief, Aviation Week & Space Technology, 2121 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.
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**WHO'S WHERE**

**Al Pichelli**, chief operating officer of Teledyne Technologies, also will be president. Robert Mehrabian will continue as chairman and CEO.  

**Marc Drobny** has been hired as president of StandardAero’s business aviation division, succeeding Marc McGowan, who is retiring. Drobny was president of Executive Jet Management.  

Euroconsult subsidiary SATConsult has appointed **David Chegnow** as deputy managing director. He was most recently Airbus Defense and Space vice president and head of strategic development, secure communications.  

**Gurpartap Sandhoo** has been promoted to the senior executive service at the U.S. Naval Research Laboratory; he will be superintendent for spacecraft engineering at the Naval Center for Space Technology. Sandhoo had been executive assistant to the director of research for technology development.  

Canadian Armed Forces Maj. Gen. **Peter Dawe** has become commander of Canadian Special Operations Forces Command, succeeding Maj. Gen. Mike Rouleau. Chief Warrant Officer **Andy Bonvie** is the command’s new sergeant major, following Chief Warrant Officer Daniel Legault.  

Gridiron Capital’s HM Dunn AeroSystems Inc. has named **Philip Anderson** CEO. Anderson succeeds **Phil Milazzo**, who will join the company’s board.  

**Universal Avionics** has named **Curtis Thelen** chief financial officer.  

**UPS** has appointed **George Willis** president of U.S. operations. Willis, a 30-year veteran of UPS operations, also will join the UPS management committee. He succeeds Myron Gray, who is retiring.  

Paris-based Eutelsat Communications has named **Jean-Claude Tshipama** head of Broadband in Africa, which promotes satellite broadband connectivity across Africa. He was CEO of Canal+ in the Democratic Republic of Congo and had been director of sales and distribution for Africa at Microsoft Corp.  

**Joe Warakomski** has been promoted to chief information officer of FlightSafety International. He joined the company in 2005 and had been deputy CIO since 2016.  

**Executive AirShare** has promoted **John Owen** to president and CEO from chief financial officer. He succeeds Keith Plumb, who has left the company.  

**Naomi Pesky** has been named vice president of strategy and stakeholder engagement for the Metropolitan Airports Commission in Minneapolis. Pesky was vice president of external relations for the Hennepin Theater Trust.  

**Airobotics**, the Israeli startup that built the world’s first fully automated drone, has appointed **Richard Wooldridge** as chief operating officer. He has held executive positions at Google and Facebook.  

**Caitlin Hayden** has joined the Aerospace Industries Association as vice president of communications. She was executive vice president and director of the media group at public relations and marketing consultancy Edelman in Washington.  

**Guardian Flight Inc.** has named **Randy Lyman** vice president of base operations for the air medical transport company.  

**Air Partner** has promoted **Ian Holder** to managing director of Baines Simmons, the compliance and safety management training arm where he has been a principal consultant since 2015. He will also sit on the board.  

**BBA Aviation’s Ontic**, an aircraft parts and maintenance, repair and overhaul provider, has appointed **Mark Gobin** as general manager of its facility in Chatsworth, California.  

Broadband connectivity provider Gogo has made several leadership appointments: **John Wade** has been named president of commercial aviation; **Sergio Aguirre**, president of business aviation; **Jon Cobin**, chief strategy officer of executive vice president of corporate development; **Anand Chari**, strategic technology advisor.  

**Ross Garelick Bell** has been appointed executive director of the Aerospace States Association. He succeeds Charles H. Huettner, who will retire in July.  

The Aviation Technician Education Council has named **Gary Hoyle** president. He had been director of campus operations for the Pittsburgh Institute of Aeronautics.  

**Bill Yantiss** has been named chief operating officer of Argus International, and **John Illson** has been promoted to executive vice president of professional resources in system management. Illson was senior vice president of certification, services and regulatory assistance. Yantiss joined Argus in 2009 and oversaw the PRISM division, a safety management systems provider.  

**Joe Lorentzen** has been hired as Middle River Aircraft Systems aftermarket and service leader, responsible for customer support management and maintenance, repair and overhaul. He had been director of product support for Gulfstream Aerospace.  

Former FAA Administrator **Michael Huerta** has joined the Delta Air Lines board of directors.  

**HONORS & ELECTIONS**  

**The Mitchell Institute for Aerospace Studies** has named former F-16 fighter pilot **Heather Penney** a senior resident fellow.  

**AirLearn** principal **Rob Britton** has received the William F. Shea Distinguished Contribution to Aviation Award from the University of Nebraska Omaha Aviation Institute.  

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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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GO BEYOND

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new multimission aircraft, the Maritime Airborne Warfare System, and development of the EuroMALE unmanned aircraft will continue with Italy and Spain (page 20-23).

**Boeing has teamed** with 10 German companies that will provide training and support for the CH-47F Chinook if it is selected to meet Germany’s STH heavy-lift helicopter requirement. The CH-47 is in competition with Sikorsky’s CH-53K.

**BAE Systems has partnered** with Farnborough, UK-based Prismatic to develop a competitor to Airbus’ Zephyr high-altitude, long-endurance unmanned aircraft. The companies will collaborate on the solar-powered PHASA-35, a 330-lb., 115-ft.-wingspan vehicle with an endurance of up to 12 months.

**Boeing’s KC-46A tanker** has completed all flight testing required for FAA supplemental type certification of the changes from the baseline 767-2C, moving it closer to a much-delayed first delivery to the U.S. Air Force.

**DARPA has canceled plans** to build and fly Aurora Flight Sciences’ XV-24A LightingStrike hybrid-electric, high-speed vertical-takeoff-and-landing X-plane after delays related to developing the 1-megawatt generator. Aurora will instead transition the technology to the commercial market (page 18).

**Greece has signed agreements** to upgrade 85 of its Lockheed Martin F-16s to the F-16V standard, with Northrop Grumman’s APG-88 active, electronically scanned array radar, at a reported cost of $1.5 billion.

**COMMERCIAL**

The FAA has mandated inspections of CFM56-7B fan blades not covered by its April 20 emergency airworthiness directive (AD). Operators must conduct ultrasonic or eddy current inspections before blades reach 20,000 cycles. The earlier AD targeted blades with 30,000 or more cycles (page 58).

**Russia’s S7 Group** has signed a letter of intent with Sukhoi Civil Aircraft Co. for 50 Superjet 75s, plus 25 options, with deliveries to begin in 2022. If formalized,

**VIEW FROM WASHINGTON**

**Privatization-Free FAA Reauthorization**

A drawn-out battle over whether or not to privatize the U.S. air traffic control system has finally ended, clearing the way for the first full reauthorization of the FAA in six years. The U.S. House voted 393-13 to approve legislation authorizing the agency’s operations through Sept. 30, 2023. The key to breaking the logjam was Rep. Bill Shuster’s (R-Pa.) recent decision to abandon his multiyear effort to move air traffic control out of the FAA and into an independent entity modeled after NAV Canada. The privatization-free House bill runs more than 350 pages. Among its provisions are a mandate to install a second cockpit barrier on new passenger aircraft operated by U.S. carriers, the repeal of a “model aircraft” exemption that had prohibited the FAA from regulating small drones and a provision allowing for the study of single-pilot cargo aircraft. The bipartisan measure now heads to the Senate, where passage is expected in May or June.

**Check 6 Aviation Week Network editors discuss the future of air traffic management now that privatization is off the table:** AviationWeek.com/podcast

**60 YEARS AGO IN AVIATION WEEK**

The Lockheed JetStar was the first business jet to enter service, made famous by celebrity owners such as Frank Sinatra, Elvis Presley and the villain in the classic James Bond movie “Goldfinger.” But the JetStar was originally developed for the U.S. Air Force as a “fast, all-weather utility aircraft.” Aviation Week’s Robert I. Stanfield flew the first prototype and evaluated it in a lengthy May 5, 1958, cover story. The JetStar “demonstrated its adaptability for training navigator-bombardiers, towing targets, doing high-speed reconnaissance and operating as an electronic or advanced trainer,” he wrote. “In addition to its qualities as a high-flying 10-passenger VIP jet transport, it can haul some 4,000 lb. of cargo.” The prototype was powered by two UK-made Bristol Orpheus engines. Later JetStars used four Pratt & Whitney JT12 engines, while the JetStar II, a follow-on version, was fitted with four Honeywell TFE731 turbosfans. All production ended by 1979.
S7 would be the launch customer for the SSJ75, a 75-seat “shrink” version of the SSJ100.

**Airbus is cutting production** of a former top-seller, the A330 widebody jet, for 2019 after losing two sales campaigns in the U.S. market. The manufacturer plans to deliver around 50 A330s and A330neos in 2019, down from 67 in 2017 and about 120 in past years.

**Boeing is to acquire** Miami-headquartered aircraft parts distribution, composites and aftermarket supplier KLX Inc.’s Aerospace Solutions Group in a deal valued at $4.25 billion, including debt. L3 Technologies is to sell its Vertex Aerospace, Crestview Aerospace and TCS businesses for $540 million.

**Rolls-Royce is to flight-test** its UltraFan large geared-turbofan technology demonstrator with Airbus under Europe’s Clean Sky 3 civil aeronautics research program, targeting entry into service from the mid-2020s with a fuel burn 25% lower than the Trent 700.

**SPACE**

**New Shepard**, Blue Origin’s privately developed reusable suborbital human space transportation system, completed its eighth test flight on April 29. The booster returned to a vertical landing at the West Texas launchpad, and the prototype crew module reached a new peak altitude of 351,000 ft. before reentering and parachuting back to a landing near the launch site.

**NASA has ordered a replacement** heat shield for its Mars 2020 rover, set for launch in July 2020, after inspections revealed the composite structure had fractured during a week-long structural test.

**View from Washington**

**A Fix for the U.S. Military’s Software Problem**

The U.S. Air Force’s new acquisition chief wants to revolutionize the way the service develops and buys cutting-edge technology—and his first step will be fixing the Pentagon’s software problem.

The Air Force’s biggest-ticket weapons systems—Lockheed Martin’s F-35 Joint Strike Fighter, Northrop Grumman’s B-21 bomber and Boeing’s KC-46 tanker—are flying computers as well as warfighting machines, reliant on advanced computing and millions of lines of code. But it is these software-intensive programs that most often rack up cost overruns and schedule delays, says Will Roper, the Air Force’s assistant secretary for acquisition, technology and logistics.

It is time for the Air Force to rethink its acquisition system so that it applies to rapidly changing software, Roper told reporters during a recent roundtable at the Pentagon. “Agile” software development, as opposed to the traditional “waterfall” model of building and releasing software in large chunks over months or even years, involves smaller, more frequent software drops, much like the way a user gets iPhone updates. “In many ways in today’s world, there is not as big of a difference from a software development mindset between developing a lot of parallel software stacks for a commercial device as there is for a military system,” Roper said. “It shouldn’t matter. If you can do it one or two times, then you can go the rest of the way, and that actually is what gives me a lot of hope in thinking about how to steer the Joint Strike Fighter program.”
COMMENTARY

UP FRONT

RICHARD ABOULAFIA

THE U.S.'S BIGGEST AEROSPACE export market is China. It also has an extraordinary and growing aerospace trade surplus with China.

According to U.S. International Trade Commission (ITC) numbers, U.S. aerospace exports to China in 2017 totaled $16.3 billion, while U.S. aerospace imports from China came to $956 million. That 17.1 lead has been growing and is now in near-record territory. In 2010, the U.S. lead was 10-1. But over the past 10 years, China's aero exports to the U.S. have risen at a 10.5% compound annual growth rate; U.S. exports to China have risen at a 12.9% rate.

There are several reasons why the U.S. lead is increasing. As a market, China is growing along with the size of its middle class population, which wants to fly, fueling strong airline traffic numbers and jetliner demand. But more important, as a supplier, China's ambitious strategy for its aerospace industry development is very badly flawed.

Consider two different models for success. One is Japan, which largely avoided national aircraft development and instead focused on joining the global supply chain. It exports billions of dollars' worth of aerostructures, composites, electronics and other high-value technologies and components. Last year, the U.S. had a modest trade surplus with Japan of 1.5-1.

Brazil represents the second model. Through Embraer, the country has focused on developing national airplanes, but always in the spirit of international trade. Embraer's designers have always had the freedom to source globally, resulting in excellent products that can compete everywhere. As a result, Embraer is a big aerospace importer as well as a big exporter. Last year, the U.S. trade surplus with Brazil was 2-1, largely due to larger jets imported for Brazil's growing travel needs.

China's 17-1 trade deficit reflects a disastrous none-of-the-above approach to aerospace development. Like Brazil, China is trying to develop national aircraft. The government recently said the ability to build and fly a large commercial aircraft is the "flower" of modern manufacturing, and the plan is to develop national jets for all requirements, including the proposed CR929 twin-aisle.

Yet unlike Brazil, China has mandated that designers restrict sourcing to Western suppliers that are willing to transfer technology, with the expectation that these technologies will be absorbed into home-grown entities creating equivalent products under the "Made in China 2025" strategy. No intellectual property (IP) protection is offered or expected.

Consequently, Chinese airplane designers are not free to import the latest and best technologies. And when Western suppliers are tapped for Chinese jets, they do not always agree to give away their best, either. Holding back the latest IP makes sense.

The results have been predictably disastrous, as evidenced by China's first production jetliner, the Comac ARJ21. Launched in 2002, it was supposed to enter service in 2007. The first production aircraft was delivered in November 2015, seven years after its first flight. Only three other ARJ21s have been delivered since, with relatively limited utilization for the small fleet. But at this point, it really does not matter; the aircraft is massively overweight and uses last-generation engines and other systems. Any airline forced to operate it will be at a severe disadvantage relative to airlines with modern equipment.

Comac's 160-seat C919 might eventually be less of a disaster, but the signs are hardly encouraging, with multiple delays and the same mandated level of technology transfer (again without IP protection). Also, China has been on this path since the 1970s, when it first developed a homegrown jet, the Shanghai Y-10. In fact, the government started referring to aviation as the "flower" of industry in the early 1980s. This failed strategy has been underway for nearly half a century.

As the Trump administration frets over China's weak protection for Western IP, it is worth considering the unintended impact the country's mandatory technology-transfer policy is having on its aerospace development strategy. And as the White House contemplates more aggressive trade action against China, it is important to remember the U.S.'s large and growing lead in aerospace. Despite its abundant talent and very large market, China is not a rising power in this industry. Looking at the numbers, in relative terms, it is declining.

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

twin-aisle manufacturing, and the plan is to develop national jets. A large commercial aircraft is the "four" of modern government recently said the ability to build and fly. Brazil, China is trying to develop national aircraft. The above approach to aerospace development. Like larger jets imported for Brazil’s growing travel needs. The U.S. trade surplus with Brazil was 2:1, largely due to aerospace imports as well as a big exporter. Last year, can compete everywhere. As a result, Embraer is a big source globally, resulting in excellent products. Embraer’s designers have always had the freedom to airplanes, but always in the spirit of international trade. Brazil, the country has focused on developing national models for success. One fawed. China-U.S. Aerospace Trade Backfring. Chinese aerospace technologies will be absorbed into home-grown entities. In fact, the government started referring to aviation as it first developed a homegrown jet, the Shanghai Y-10. Also, China has been on this path since the 1970s, when it developed the ARJ21. Launched in 2002, it was supposed to enter service in 2004. The results have been predictably disastrous, as evidenced by China’s first production jetliner, the Comac C919. Holding back the latest IP makes sense. Any airline forced to operate it will be at a severe disadvantage relative to airlines with last-generation engines and other systems. Any airline forced to operate it will be at a severe disadvantage relative to airlines with last-generation engines and other systems. Any airline forced to operate it will be at a severe disadvantage relative to airlines with last-generation engines and other systems. Any airline forced to operate it will be at a severe disadvantage relative to airlines with last-generation engines and other systems. Any airline forced to operate it will be at a severe disadvantage relative to airlines with last-generation engines and other systems. As the Trump administration frets over China’s growing and is now in near-record territory. In 2010, China came to $956 million. That 17:1 lead has been totaled $16.3 billion, while U.S. aerospace imports from China-U.S. International Trade Commission (ITC) numbers, U.S. aerospace exports to China in 2017.
Psychosomatic Stress?

**Suppliers squeal** as Airbus, Boeing eye rate increases

But industry is making peace with many of those issues in the near term, as any consequences seem far off. Instead, another matter is becoming the leading bone of contention: whether the supply chain is ready for additional production rate increases in large commercial aircraft, especially as the big four—soon to be just two—OEMs tighten their screws on suppliers.

Morgan Stanley analysts said in a mid-April report that they expect announcements on production rate hikes this quarter or next—by October—and from Airbus potentially before Boeing, as the latter contends with rising U.S. trade risk and supplier execution questions. “We now assume Airbus reaches 63-70 per month for 2019-2021 and Boeing reaches 63-70 for 2020-2021,” they wrote. This equates to roughly 10% narrowbody growth annually over the next five or so years.

But the analysts note increasing hiccups are emerging, citing reports that Airbus is temporarily shelving development of “plus” models of the A320 and A321, given supply-chain challenges around current models. Problems with engine availability have also been well-documented, as have previous issues with interiors supply from Safran’s Zodiac Aerospace. “These possible headwinds have also showed up at Boeing, where a key supplier in Spirit AeroSystems has encountered setbacks, as have others such as Arconic,” they say.

United Technologies Corp. (UTC) Chairman and CEO Gregory Hayes already is nervous. “A very slow, measured increase in output is probably fine, but if you see big order jumps, that is going to be a problem,” he said April 24.

“The bottlenecks are not in our assembly and test facilities; it really goes into the supply chain and not even the first-tier suppliers. You’re talking second-, third-tier suppliers, and one of the biggest shortages we are seeing is not material, but workers,” he says. “That’s a global issue that we’ve got.”

Hayes’ comments about the supply chain were not the first time he has expressed caution about upward production rates. But they come as Airbus openly debates increasing production, with some executives dismissing concerns over suppliers.

“The industry has changed dramatically,” Airbus executive vice president for sales, marketing and contracts Eric Schulz said during the recent Singapore Airshow. “The supply chain will continue to be able to cope, so that we will be able to raise rates as needed.”

Boeing executives have sounded the same note at times. During an MRO Americas presentation, Stan Deal, CEO and president of Boeing Global Services, pushed back against frustrations expressed by audience members about his Chicago company’s insourcing and Partnering for Success initiatives. He says he sees healthy profit margins in the supply chain, and besides, business conditions are changing and everyone simply has to keep up or move on, OEMs and suppliers alike.

But Boeing Chairman, CEO and President Dennis Muilenburg has at least sounded more considerate. “We are ever vigilant on our supply chain,” he said April 25. “We know there will be pressure points as we ramp up, but we are confident that we will continue to ramp up and hit our delivery marks.”

For UTC, which provides the Pratt & Whitney geared turbofan engine among other aircraft parts and systems, the issue is acute. “We have spoken to Airbus, we know there is a desire to increase that, and we are committed to take that rate up over the next couple of years,” Hayes says. “But I think there is a question beyond that [of] whether or not the sub-tier suppliers really have the capacity. And that is what we’re working through with Airbus and Boeing: Is there enough capacity in the supply chain that you’re not going to see big bottlenecks?”

He adds, “Having been around long enough, we’ve seen this a couple of times, and as we have ramped up production, the supply chain just can’t keep up.”
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Churchville’s checkout was in preparation for a cropdusting assignment with Ciba-Pilatus Ltd. in the cotton- and milo-rich Gezira region of central Sudan. There, he and fellow expats would alternately use the aircraft to transport equipment, people and supplies to their remote base, and then swap out seats for a 300-gal. tank, dispensing lines and nozzles under the wings, and go kill grain-attacking pests.

Over the past six decades, Pilatus says nearly 600 Porters were delivered, most out of Stans, although Fairchild-Hiller built about 90 of them under license in the U.S. Initially, the aircraft was powered by a piston engine until being supplanted by Turbo meca’s Astazou turbo-prop, but that proved problematic. Fairchild fitted its machines with the Garrett TPE331 engine, but the Pratt & Whitney Canada PT6 has by far been the engine of choice, powering approximately 425 Porters, some of which were refitted with it.

The PT6 is a Pilatus favorite, also powering its military trainers and the PC-12 high-performance passenger and utility civilian models with more than 1,500 delivered. That aircraft is now joined by the PC-24 utility twinjet, the first turbofan model offered by Pilatus. And that lineup seems to mark the end of the line for the Porter.

Demand for the $1.9 million (instrumented) workhorse has slowed considerably, with just 52 delivered over the past decade. Last summer, Pilatus Chairman Oscar J. Schwenk acknowledged that the Porter has “earned us fame and recognition worldwide,” but noted that “every product has a life cycle which must come to an end sooner or later. That moment has arrived for the PC-6.”

Accordingly, the company will cease accepting orders this summer, and the final Porter will roll off the line in early 2019. The company says it will continue making parts to support the existing fleet for at least 20 years. That is reassuring, since Porters can last a long time. The fourth one—built in 1959—is still in operation with Icarius SAR of France.

The production knell has sounded for one of aviation’s most iconic and versatile aircraft. One, Churchville attests, that when flown in beta down the side of Mount Pilatus provides its pilot with “a metaphysical experience.”

William Garvey is Editor-in-Chief of Business & Commercial Aviation
WHEN ETIHAD AIRWAYS’ NEW CEO TONY DOUGLAS walked onstage at the Emirates’ Global Aerospace Summit, his audience was all ears. Douglas has now been in his job at the smallest of the big three Gulf carriers for around five months and has so far kept quiet about the direction in which he wants to take the airline. But what he offered as guidance left much open. He was prepared to say only that it “remains to be seen” whether “the pace of growth will be quite as aggressive as in the past.” He added that Etihad has “made a mistake or two” but has learned from the Alitalia and Air Berlin experiences.

Douglas’ comments indirectly offered more insight into the shifting balance of power in Abu Dhabi’s aerospace/aviation community than where the airline is going. Clearly, the new CEO did not say more about his future strategy because he couldn’t. Other forces in the emirate are now much more closely involved in the airline than in the past and have yet to agree on its future.

To recap, Etihad for years pursued its own rapid expansion to catch up with Emirates and Qatar Airways, building up a similar network—resulting in the three carriers serving many of the same destinations. In addition, Etihad bought into foreign airlines to build up even more quickly. Unlike Qatar Airways later, which predominantly targeted industry blue chips such as International Airlines Group or LATAM Airlines, Etihad went after failing carriers like Air Berlin and Alitalia. Although it spent billions on stakes and rescue aid, it was unable to turn them around.

Despite the huge cash outflow toward questionable investments, Etihad’s former management under CEO James Hogan was left alone for surprisingly long, with the board seemingly ignoring alarms that should have been easy to detect. Following the departure of Hogan and much of senior management early last year, Abu Dhabi’s ruling family, the Al-Nahyans, are plotting a different course. The government established a strategy committee representing various constituencies, including the emirate’s large investment fund Mubadala, to determine the airline’s future role.

Mubadala’s heavier involvement is good news in principle. The fund is all about business and does not seem much interested in the rivalries with Emirates and Qatar. Whatever Etihad does must make business sense either for Abu Dhabi’s economy as a whole or at least for Etihad—ideally for both.

Etihad’s problem is that quick guidance is unlikely. The more players there are on the committee, the longer it takes to decide anything. And unlike Dubai, known for its fast decisionmaking, Abu Dhabi has taken longer in the past to come to any conclusions.

The last 25 or so years in the emirate’s aviation history have been dominated by extremes. Before Etihad was set up 15 years ago, the richest of the emirates did not even have its own airline. It owned a stake in Gulf Air, which had to spread its network between three bases, including Bahrain and Oman. Then came Etihad and its almost unprecedented growth. Clearly, Abu Dhabi will never return to not having an airline, but Etihad also will not grow much in the foreseeable future. It is actually now pulling out of a significant number of long-haul routes.

Political influence is an issue Douglas has to deal with, but there are other constraints as well. Etihad still has substantial orders for both Boeing and Airbus widebodies in place. They are not quite as large as those of Qatar and Emirates, but are nonetheless a major headache.

If management cannot find an elegant way of disposing of them, all the aircraft coming in over the next several years will need to be used sensibly. On the other side of the apron, the much-delayed new midfield terminal is slowly taking shape. When it opens, Abu Dhabi will have an airport built to serve the long-haul connecting model—exactly the one being questioned by those who think the airline should focus on serving only routes that are important to the Abu Dhabi economy, rather than on competing with its much bigger neighbor down the (Sheikh Zayed) road.

It is hard to see how Etihad, having posted massive losses of late, can be made profitable in the near future. It will have to continue to rely on support from its only shareholder, the government of Abu Dhabi—much like Qatar Airways has to rely on Qatar as it struggles to deal with the massive fallout of the continuing airspace blockade by most of its neighbors.

Ironically, it appears that the U.S. and the United Arab Emirates are about to sign a nonbinding supplemental agreement to the existing open skies deal that includes language about becoming more financially transparent and, reportedly, the intention not to introduce fifth-freedom services to the U.S., at least for now. The prospect of Gulf carriers flying between Europe and the U.S. worried the big three American airlines so much that they were prepared to invest multiple millions in an anti-Gulf carrier lobbying campaign, but that has gone very quiet of late. ☛
NO ONE EXPECTED the electrification of aircraft propulsion to be easy, but DARPA's decision to cancel an ambitious hybrid-electric flight demonstrator is a harsh dose of reality for the industry. Aurora Flight Sciences' highly unconventional XV-24A LightningStrike had become a flagship for the much-vaunted new era in aviation.

In pulling the plug on the hybrid-electric, distributed-propulsion vertical-takeoff-and-landing (VTOL) X-plane, the Pentagon's advanced research agency cites the strong commercial interest in the technology that has emerged since the program was launched in 2013 and the lack of a service partner to which the technology could be transitioned on completion of the program.

But the flight demonstrator was already facing challenges, among them development of the powerful generator at the core of the hybrid-electric drivetrain. This is a fraction of the size of existing megawatt-class generators, with higher efficiency—98% versus a more usual 92%. But, crucially, it has five times the power density of existing generators, enabling megawatt-class power levels on electric aircraft.

The LightningStrike was to be powered by a Rolls-Royce AE1107 turboshaft driving a gearbox mounting three of these generators. They were to power 24 variable-pitch ducted fans, 18 embedded in the aft tilting wing and six in the tilting canard foreplane. AC power flowed directly to the motors, rather than being converted to and from DC for distribution—a unique synchronous power approach that saved weight.

Honeywell acknowledges the challenges in developing such a power-dense generator but says the prototype is scheduled to be tested at full 1-megawatt power at Florida State University in July and is on track to achieve the planned technology readiness level 6. The company is adamant the extra work required to overcome heat management issues was not a driving factor behind DARPA's decision.

This is not the first ambitious electric-aircraft X-plane to encounter challenges. In December 2016, the powerful lithium-ion battery for NASA's X-57 Maxwell electric-propulsion demonstrator destructively failed a thermal runaway test. The battery had to be redesigned to improve containment so a short-circuit in one cell cannot propagate to other. The redesigned battery passed the safety test in late 2017 and the X-57 is on track to fly this year, but valuable lessons were learned.

Aurora did fly a subscale demonstrator (SSD) under DARPA's VTOL X-Plane program, which the company says achieved several key milestones, including demonstrating distributed-electric ducted-fan propulsion, synchronous electric power and tiltwing/tiltcanard VTOL. Aurora now plans to apply those technologies to its commercial electric-vTOL (eVTOL) development work in partnership with Uber.

Flown in April 2017, the 20%-scale SSD proved both a blessing and a curse for the LightningStrike. It validated the propulsion system concept, its hover and cruise efficiency and the flight control system planned for the full-scale aircraft. But its success allowed DARPA to declare that “the major objectives of the VTOL X-Plane program were achieved with the subscale demonstrator.”

Experience gained flying the subscale aircraft did enable Aurora to quickly fly a similar-sized demonstrator of its simpler eVTOL concept for Uber. And under the terms of the LightningStrike termination, the company gets to keep the SSD, which is expected to fly again in support of its eVTOL development.

The program also faced hurdles that are uniquely DARPA's. First, the agency's priorities are constantly changing and have shifted toward areas such as hypersonics, so terminating VTOL X-Plane freed up funds. Second, DARPA programs normally require a service partner to proceed into flight testing, but VTOL X-Plane deliberately avoided specifying a mission set to encourage the most innovative ideas. And that made finding a transition partner more difficult.

But it is challenges faced in developing a megawatt-class hybrid-electric propulsion system that provide a lasting lesson. Some key startups in the electric-aircraft market are developing their own motors and generators because a supply chain does not yet exist. But getting to megawatt-class, and beyond, may not prove as easy as they hoped. Enthusiasm for electric propulsion may not be reduced by the premature burnout of the LightningStrike, but an edge of realism has been introduced.
COMMENTARY

THE LAUNCHPAD

IRENE KLOTZ

THE THOUSANDS OF SMALLSATS heading to launchpads in 5-10 years promise seamless, global connectivity, near real-time Earth imagery and navigation services for our self-driving cars. But whether they will deliver depends in part on how well the birds share increasingly congested low Earth orbit (LEO).

Legislation passed by the U.S. House of Representatives on April 24 authorizes the Department of Commerce to begin tackling the issue of space debris by requiring companies to submit plans for removal of their defunct spacecraft from orbit. The American Space Commerce Free Enterprise Act, H.R. 2809, passed by voice vote with bipartisan support. It now moves to the Senate.

In parallel, the National Space Council, headed by Vice President Mike Pence, is recommending President Donald Trump similarly shift responsibility for issuing space traffic notifications to the Commerce Department as part of a regulatory overhaul aimed at creating a “one-stop shop” for U.S. companies wishing to operate in LEO and beyond.

“Since the launch of Sputnik in 1957, more than 45,000 objects have been launched into space. Nearly half of those objects are still in orbit today, yet only a few thousand still serve a useful purpose. All others are considered debris, an unfortunate byproduct of decades of human activity in space,” Andrew Abraham, with The Aerospace Corp. Center for Space Policy and Strategy, writes in a recently released policy paper.

The Air Force tracks about 20,000 objects about as big as a softball or larger in Earth orbit, but that number is expected to grow exponentially due to improved surveillance technology (an S-band digital array radar, capable of seeing objects the size of a marble in LEO, is expected to begin operating in 2019) and upcoming mega-constellations of satellites.

“We are in a rapidly changing world,” says Aerospace Corp. Vice President Jamie Morin. “If these large constellations in LEO for communications and other purposes go up as planned . . . we could do more in 5-10 years by a factor of two, three or more than we have since Sputnik. This is a pretty important period of time.”

Commerce Secretary Wilbur Ross, who has embraced commercial space as a way to grow the U.S. economy, says his agency will learn from the Air Force and take over space traffic management notifications as it gains expertise, insight and operational experience. “Our mutual understanding is things are only going to get handed over as they are seamless [with] total assurance it is going to work right,” he said on the sidelines of the April 16-19 Space Symposium in Colorado Springs.

To kick off the process, Ross says the agencies are talking about embedding personnel in each other’s organization. “What’s not going to happen is there’s a switch turned one day and suddenly it’s a whole new ballgame . . . . It’s going to be much more evolutionary, with a lot of training in between,” he says.

The Air Force tracks about 1,900 active satellites, not all of which are capable of maneuvering. Last year, satellite operators reported 102 collision-avoidance maneuvers in near Earth orbit and seven in deep space to the 18th Space Control Sqdn. (SPCS), a space surveillance unit located at Vandenberg AFB in California.

The 18th SPCS continuously monitors tens of thousands of man-made objects in Earth orbit, predicts their future orbits and compares that information against all objects in a database generated by the Space Surveillance Network, which uses a combination of ground- and space-based radars and optical telescopes to track and characterize objects circling Earth.

Space Cop

Commerce Department to take over job of space traffic management

The 18th SPCS compares the predicted orbital characteristics of all space objects to determine if two are going to closely approach each other; a process known as Conjunction Assessment. If a close approach between two objects meets reporting criteria, 18 SPCS issues notifications via its public website, Space-Track.org.

“Two types of notifications are automatically disseminated: conjunction data messages (CDM) and close-approach notification (CAN) warnings. CDMs are provided as data to help satellite operators plan for and mitigate risk; most CDMs do not meet high-concern criteria. CAN warnings are only provided for close approaches that meet high-concern criteria,” the Air Force writes in an email.

In 2017, the 18th SPCS issued more than 4 million CDMs, but only 20 per day met the very high-concern level, the Air Force said.

The same level of spaceflight safety services is provided to all active satellite operators and owners, including those operating cubesats, whose 10-cm² (1.5-in²) size is about the smallest that can be optimally tracked by the Space Surveillance Network.
Ten months after German Chancellor Angela Merkel and French President Emmanuel Macron revealed joint ambitions to produce a new European fighter jet, the first pieces have begun falling into place.

Heralding a new era of European multinational defense programs, Airbus and Dassault Aviation are putting aside years of fierce competition to work side by side on the Future Combat Air System (FCAS), while France will take the lead in platform development.

The fighter is the flagship in a wave of new cooperative programs European governments hope to use to strengthen their resolve against a resurgent and increasingly aggressive Russia, as well as to halt the tide of European cash flowing into U.S. coffers for new armaments.

Europe's aerospace players say the region's defense sovereignty and industrial capability are at stake from a free flow of U.S. defense exports such as the F-35 Joint Strike Fighter and Patriot air defense system. They believe the fighter project, at an estimated €80 billion ($97 billion), is a small price to pay to preserve that.

"This is a decisive step for the defense of Europe," said French defense minister Florence Parly, green-lighting the joint program at the ILA Airshow here on April 26. "In just 10 months, we have managed to unite around a concrete, common, ambitious project. . . [Europe] must take its destiny into its own hands," she added.

The first step will be joint studies, before a development program to map the way toward a technology demonstrator flying by 2025. A prototype could emerge in the early 2030s, with the first operational aircraft replacing Dassault Rafales and Eurofighter Typhoons starting in 2040.

In the coming weeks, expect the formation of a joint venture to develop the fighter's advanced engine, as studies consider the advanced sensors and the weapons to ultimately arm it.

Now industry is urging governments to begin providing funding and kick-start the project.

"Never before has Europe been more determined to safeguard and foster its political and industrial autonomy and sovereignty in the defense sector," says Airbus Defense and Space CEO Dirk Hoke. But the schedule is tight, he warns. "We need to start working together immediately by defining a joint road map on how best to meet the requirements and time lines to be set by the two nations," he adds.

A similar view is shared by engine manufacturers. MTU Aero Engines has begun lobbying Germany's defense ministry to start funding research and development. MTU says if technology development is to conclude in the mid-2020s, funding is needed immediately to ensure an engine can be ready for a prototype to fly in the early 2030s.

France is taking the lead on the program in part because Germany already has that role on two other cooperative programs, the EuroMALE unmanned air system (see page 23) and joint development of a new main battle tank. Plus, France is one of just a handful of European countries that produce combat aircraft unilaterally, the Mirage and the Rafale. The latter resulted from Paris' decision to withdraw from the European Fighter Aircraft (EFA) program in 1985. The EFA eventually produced the Eurofighter. Airbus and its forerunners have only played a shared role in fighter programs such as the Tornado and Typhoon.

And while the two countries appear
While the existing fleet of Eurofighters will be phased out with the introduction of the FCAS, those introduced as a replacement for the Panavia Tornado could fly until 2060.

Airbus and Dassault say FCAS is not simply a new fighter but a range of elements connected and operating together, albeit with a manned fighter at its heart—although unmanned versions could emerge later.

The FCAS is targeted at replacing the Eurofighter and Rafale, but may also need to be navalized to replace the Rafales operating from the deck of France’s carrier, the Charles de Gaulle.

MTU revealed it is engaged in initial studies on its New European Fighter Engine. While the company says it has the capabilities to develop an engine on its own, it is ready to use its specialties in collaboration with French industry.

Technologies being proposed by MTU for the powerplant include a variable-cycle system, which it says will optimize fuel economy and mission flexibility. The company has been experimenting with the technology on a small scale for the last decade. Other technologies envisioned include additive manufacturing for engine production and in-service support.

Engineers want to take a “bionic” approach to the engine’s design to make best use of additive manufacturing capabilities. Senior engineers say MTU is ready to support either a single-engine or twin-engine configuration; the latter is most likely given the propensity for twin-engine fighter types, at least in the German armed forces.

But the FCAS still faces significant hurdles. Germany needs to replace its aging Panavia Tornados while also spending on the FCAS. The Tornado replacement program covers the potential purchase of up to 90 new fighters at a cost of €15-20 billion.

Both Airbus and the U.S. government delivered their answers on April 23 to a German request for information, which questioned how each of the potential Tornado replacements would take on its numerous roles.

Airbus is offering a comprehensively upgraded version of the Typhoon with integration of additional weaponry and enhanced performance from the Eurojet EJ200 engine, arguing the Eurofighter would be a more cost-effective approach than introducing a new U.S. type. Furthermore, they say a new batch of Eurofighters would help bridge the gap and support industrial development of the FCAS system.

The U.S. is making a play for the F-35 Joint Strike Fighter, but also for advanced versions of the Boeing F-15 Eagle and the F/A-18 Super Hornet combined with the EA-18 Growler. All four competing types were present at the show.

In November, German Air Force chief Lt. Gen. Karl Mullner said his country wants a fifth-generation platform to replace the Tornado, inferring the F-35 was the “benchmark” option. However, German politicians were quick to distance themselves from the comments, and reports have suggested his remarks may have resulted in his enforced early retirement, planned for the end of May. The politicians are said to prefer the Eurofighter.

But even the possibility of an order for a U.S. platform, particularly the F-35, is causing some concern in European industry. In the lead-up to the show, Hoke warned that German procurement of the F-35 could end future fighter cooperation with France.

“As soon as Germany becomes an F-35 nation, cooperation with France on all combat aircraft topics will die,” Hoke told a German newspaper on April 22.

But Lockheed Martin later countered the statement, saying operating a fifth-generation fighter could be “complementary” and a “leg up” to a future European program.

—With Jens Flottau in Berlin
Germany’s plan to replace the Panavia Tornado strike aircraft appears to be emerging as a two-horse race between the Eurofighter Typhoon and the U.S. F-35 Joint Strike Fighter.

Airbus, one of the industrial partners in the Eurofighter consortium, and the U.S. government working with potential fighter suppliers Boeing and Lockheed Martin, delivered their answers to a formal request for information (RFI) on April 22 on the eve of the Berlin ILA Air Show.

And the stakes are huge: Germany’s requirement is potentially the largest fighter procurement in Europe for a decade. Industry officials say Berlin is looking for as many as 90 aircraft, replacing the Tornado fleet on a one-for-one basis. Finland, the next largest procurement is looking for 64 jets.

A deal could be worth €15-20 billion ($18-24 billion).

The RFI called on the manufacturers to answer how they would address the 10 missions performed by the Tornado fleet. It also asked how it could operate with the platform that ultimately emerges from the Franco-German Future Combat Air System (FCAS) program, which was also given the political green light at the show (see page 20).

On offer from Boeing are advanced versions of the F-15 Eagle or a mixed fleet of F/A-18 Super Hornets and EA-18G Growlers electronic-attack aircraft. The Growlers would likely suit Germany’s need to replace its Tornado ECR aircraft tasked with the suppression and destruction of enemy air defenses (SEAD/DEAD). Meanwhile, Lockheed Martin is offering the F-35A Lightning II, but the prospect of Germany becoming an F-35 customer has already created controversy.

Last year, a senior German Air Force officer openly expressed a preference for a fifth-generation platform like the F-35, but German politicians have distanced themselves from such remarks.

Of course, both platforms come with their advantages and disadvantages. With the F-35, Germany would be buying into a vast program with a wealth of experience, and the aircraft would already be in service with several European nations. But the same could be said for the Typhoon.

What separates the F-35 from the Typhoon is the aircraft’s low-observability features and its apparent ability to gather up battlefield data, a capability no doubt detailed by Washington when Germany received classified briefings last year. But buying F-35s means additional costs in terms of infrastructure, and not all of Germany’s weapons can be integrated onto the platform.

Purchasing the Typhoon comes with its own challenges. Although the consortium envisions putting a range of new weaponry onboard—including the Kongsberg Joint Strike Missile, the Taurus air-launched cruise missile and an anti-radiation missile for the SEAD/DEAD mission—funding these and other enhancements also will require the support of the other partner nations.

Weapon integration on the Eurofighter can be a costly business. Another challenge for the Typhoon will be getting the jet wired and certified by the U.S. to carry the B61 nuclear bomb, enabling Germany to continue its NATO deterrence mission through dual-key arrangements with the U.S. B61 capability will be enabled on the F-35 in the early 2020s. Eurofighter officials say they are confident the certification issues related to the B61 will not be used as “leverage” to adopt a U.S. platform.

But replacing the Tornado with additional Typhoons would leave Germany operating a single fleet of combat aircraft for roughly a decade (based on the FCAS program time lines), not always desirable in the event of a technical problem. The country has grounded its Typhoons several times in recent years due to relatively minor technical issues.

Other planned improvements to the Typhoon as a Tornado replacement include the new electronically scanned array radar under development. And the Eurojet EJ200 engine will be tweaked to provide up to 15% more power in some elements of the flight envelope, a reflection perhaps of the heavier standoff weapons the Eurofighter will be carrying, a counter to the F-35’s stealth argument.

Key to the argument for the Typhoon is the retention of Germany’s defense sovereignty. “There are no black boxes,” says Eurofighter CEO Volker Paltzo. Germany, he says, has “access to all data in the [Typhoon] program.”

Furthermore, a German decision could help trigger Typhoon purchases elsewhere in Europe, such as in Belgium, Finland, Poland and Switzerland. The company believes there are opportunities for the sale of 300 additional aircraft, including the potential 90 for Germany.

Details about the next steps for the program remain unclear, but Berlin has promised a “comprehensive and balanced evaluation” of all the aircraft types.
**Surveillance Drone Is a Test of European Cooperation**

> TWIN-ENGINE TYPE IS COMPROMISE FOR EUROPE’S AIRSPACE
> DESIGN FREEZE PLANNED FOR YEAR-END

**Tony Osborne  Berlin**

Europe is finally committing to the development of a surveillance drone to rival those of its competitors in China, Israel and the U.S.

With the backing of the French, German, Italian and Spanish governments, the EuroMALE unmanned air system (UAS)—being developed by Airbus, Dassault and Leonardo—is the first major new cooperative aerospace project in Europe since the A400M and, officials say, it is a key stepping-stone for other multinational programs, including the new European fighter (see page 20).

The unveiling of a full-scale mockup of the aircraft here at the ILA Berlin air show on April 26, following a two-year definition study, comes as Europe attempts to reinvigorate its defense industrial base. Following years of cuts, European governments are beginning to spend on new gear; and cooperative programs are receiving a boost from the European permanent structured cooperation initiative and creation of a European Defense Fund for research and development.

But EuroMALE lags behind U.S. products such as the General Atomics MQ-9 Reaper, which has secured a stronghold in Europe. France and Italy are already operating the U.S.-made platform; Spain is likely to follow suit.

Also, the Trump administration is loosening restrictions preventing the export of some U.S.-built platforms—even to some key coalition partners. The red tape entanglement left the market open for countries like China and in the Middle East with what U.S. State Department officials have called “knock-offs” of U.S.-developed systems.

However, the partners are focusing on the home nations first, meeting what Airbus Defense and Space CEO Dirk Hoke describes as “urgent capability requirements” of European armed forces. Any exports would depend on the policies of the participating nations, he points out.

Service entry is expected in 2025.

The definition study has resulted in a twin-turboprop air vehicle that closely resembles the configuration of BAE System’s Mantis UAS, the forerunner of the Telemos platform, which was under development by France and the UK until its abandonment in July 2012.

Like Mantis, the EuroMALE’s engines are mounted behind the wing in a pusher configuration, although it seems to be considerably larger. Initial estimates peg the aircraft as about one-third larger than the MQ-9. German magazine Flug Revue stated the EuroMALE’s gross weight as 11 metric tons.

Airbus had previously proposed designs similar to the Talarion platform it has offered for previous European medium-altitude, long-endurance programs. Both Dassault and Leonardo had also publicly displayed jet-powered platform designs.

Hoke says the selection of a twin-engine configuration was a compromise to ensure the platform could be civilian certified and operated in nonsegregated airspace, perhaps to meet German legal requirements, a government communique published in July 2017 suggests.

Design and configuration of the EuroMALE is not yet frozen, and suppliers for key elements such as the engines and internal systems have not been announced. A system preliminary design review (PDR) planned by year-end could begin to gel the details. The three companies say the platform will feature “mission modularity,” suggesting it could carry a range of payloads including wide-area sensors.

The platform has also been designed to be armed as an option. France intends to arm its EuroMALEs, possibly with the MBDA Brimstone missile.

Hoke says all four governments have submitted estimated orders so the three companies could provide pricing for the program. Paris plans to order six systems, each equipped with three aircraft and two ground stations to replace its Reaper fleet.

No details have yet been provided about the workshare, but Leonardo has extensive experience on the integration of sensors and mission systems into UAS, having worked on Piaggio’s P1.H Hammmerhead UAS. This makes it a likely candidate for that task.
While stopping short of consolidation, tie-ups announced at the Association of Unmanned Vehicle Systems International’s Xponential show here on April 30-May 1 reveal an industry responding to the demands of large-enterprise customers on the commercial side and evolving missions on the defense side.

Airbus Aerial, the satellites-to-drones remote-sensing business established a year ago by Airbus, has partnered with DroneBase, the largest global drone operations company, to provide aerial imagery and data analysis to large customers. Airbus Aerial was formed to combine the imagery from satellites, aircraft and drones and provide data to the insurance, construction, utility, rail and other industries, and DroneBase provides access to tens of thousands of drone operators that can provide imagery and data on almost any location across the U.S. within 48-72 hr., says Jesse Kallman, president of the Airbus company.

Boeing subsidiary Jeppesen has teamed with Kittyhawk, a leading provider of drone operations management software, to provide digital authorization to operate in controlled airspace and simplify commercial operations by UAS. Boeing is one of the first of the new breed of UAS service suppliers—USS—approved by the FAA to provide automated airspace access via the Low-Altitude Authorization and Notification Capability (LAANC). The first step toward an automated UAS traffic management system, LAANC is being expanded to almost 300 air traffic facilities and 500 airports.

Commercial drone flights are limited to within visual line of sight of the operator, but PrecisionHawk is claiming a breakthrough in beyond-visual-line-of-sight (BVLOS) operations that could position UAS to begin replacing manned aircraft for longer-range missions such as powerline and pipeline inspection. Under the FAA’s Pathfinder program, the company has developed a safety case enabling flights up to 50 mi., which CEO Michael Chasen describes as “game changing.” PrecisionHawk’s BVLOS multirotor drone
is equipped with real-time airspace awareness, an acoustic sensor for detect and avoid, a hybrid-electric engine for 2-hr. endurance and a ballistic recovery parachute.

Another Pathfinder participant, BNSF Railway, has developed a BVLOS capability for track inspection and is now flying 900 mi. a day over three subdivisions in the U.S. Operations use a redundant command-and-control radio network developed with Rockwell Collins, ground-based sense-and-avoid radars in key areas near airports and Latitude Engineering’s HQ-60B hybrid vertical-takeoff-and-landing (VTOL) UAS, which can land on the rails if there is a problem. BNSF is now developing an airborne sense-and-avoid capability so it can scale up operations, says Todd Graetz, director of UAS technology services.

In another development, Israel’s Airobotics is working with the FAA to bring its remote-operated BVLOS drone-in-a-box system to the U.S. The company is already approved to fly over industrial sites, mines and oil-and-gas facilities in Israel and Australia; its automated drones are managed from a remote operations center, eliminating the need for an on-site pilot. Data generated to gain approvals for the Israeli and Australian aviation authorities is being provided to the FAA, says Richard Wooldridge, Airobotics chief operating officer. Mining companies BHP in Arizona and Minera Centinela in Chile are the most recent customers.

On the platform side, the rapid development of commercial technology evident across the exhibition hall at Xponential has attracted the attention of a defense industry responding to new requirements. Leading military small UAS manufacturer AeroVironment is to incorporate VTOL technology from commercial drone developer FlightWave Aerospace Systems into its next generation of tactical UAS.

FlightWave’s Edge hybrid tricopter/fixed-wing UAS provides VTOL capability with increased speed, range and endurance compared with conventional multicopters, and AeroVironment will incorporate the technology into future small UAS to follow its fixed-wing Puma and Raven. “By working with FlightWave, we can speed the delivery of next-generation capabilities to our customers,” says David Sharpin, vice president of tactical UAS.

L3 Technologies, meanwhile, is to produce Latitude Engineering’s HQ-60 hybrid VTOL UAS as the FVR. Latitude plans to remain a research and development house and says L3 will manufacture the HQ-60 for both the military and commercial markets, including for BNSF. Latitude says it is already working with L3 and U.S. Special Operations Command to adapt the UAS to carry blood to forward locations.

Military technology is also flowing the other way, with Boeing subsidiary Insitu unveiling a commercial, exportable and certifiable ScanEagle3 version of its long-endurance small tactical UAS. The U.S. State Department has ruled the ScanEagle3 is not covered by International Traffic in Arms Regulations and so is exportable globally, says Insitu. The UAS is aimed at markets such as infrastructure inspection, maritime surveillance, wildfire monitoring, security and communications.

The new version is compatible with existing ScanEagle payloads, uses the same launch-and-recovery equipment, and is integrated with Insitu’s existing commercial ground control station software, which allows multiple, dissimilar aircraft to be flown simultaneously. But ScanEagle3 can carry up to three payloads at once for increased flexibility. A new design with twin tail booms and ground-adjustable wing positioning provides a larger center-of-gravity range, enabling a wider range of payload options as well as rapid payload changes in the field, the company says.

Textron Systems Unmanned Systems has revealed a hybrid rotary/fixed-wing engineering testbed that is clearly influenced by commercial developments but is being used to develop technology for future tactical UAS. The X5-55 is a 55-lb.-class all-electric UAS that combines a flying-wing configuration for cruise efficiency with independent thrust-vectoring rotors for propulsion and control in both vertical and forward flight. The air vehicle has no traditional aerodynamic control surfaces, for simplicity.

The UAS first flew in July 2017 and was developed by Textron Systems Unmanned Systems advanced products team as a testbed for technologies to expand UAS capabilities in expeditionary environments. While the X5-55 is a testbed, the technologies being developed are being applied to “other platforms in development that will be coming out in the next few months,” says William Irby, senior vice president and general manager of Textron’s Unmanned Systems division.

Unmanned Aircraft, Bomb-Disposition Robots Cooperate in U.S. Navy Project

> EOD ROBOTS CAN BE TRANSPORTED AND OPERATED OVER 50 MI.

> VEHICLES COULD AID IN CHEMICAL, NUCLEAR, NATURAL DISASTERS

Graham Warwick Denver

U.S. Navy project to airlift bomb-disposal robots by unmanned helicopter and remotely operate them over distances up to 50 mi. is heading toward a key flight demonstration in June. The system would enable a faster, safer response to threats such as roadside bombs.

The CURRE project—for Cooperative Unmanned Air Systems (UAS) and Robots for Remote Explosive Ordnance Disposal (EOD)—is a joint program by the Naval Air Warfare Center at Patuxent River and Naval Surface Warfare Center (NSWC) at Indian Head, both in Maryland. The Navy is a lead service for EOD within the U.S. military. Robots that can defuse bombs are operated at short range because of the high-definition video and low-latency commands required to provide a disposal expert with the telepresence needed to control the machine through the intricate task of inspecting and disabling an explosive device.

Underway since October 2017, the CURRE project is developing not only the ability to deploy an EOD robot by unmanned aircraft but also the high-bandwidth, low-latency communications required to then remotely operate the machine when it is in place.
The operating concept is to load the EOD robot into a crate that is then picked up by a helicopter, unmanned or manned, and carried externally as far as 50 mi. The crate is then lowered to the ground, and the robot drives out. The helicopter climbs, then loiters to provide a communications relay.

When an improvised explosive device is encountered, airlifting the robot would be safer than driving on the road and quicker than undertaking the clearance operation required to ensure the road to the site is safe, says Carl Fahrner, a systems engineer with Naval Air Systems Command’s autonomy initiative.

The ability to airlift EOD robots over significant distances “and get robotic eyes on the scene quicker” would prevent human disposal experts wasting their time responding to false alarms, he told the Association of Unmanned Vehicle Systems International’s Xponential show in Denver on April 30.

“Robotic EOD is about telepresence, not automation,” says Aaron O’Toole, a robotics engineer with NSWC Indian Head’s EOD technology division. “Bomb disposal is not easy to automate. The human is always needed. Hence the importance of high-def video and low-latency communications.”

The communications requirements are demanding—high-definition video needs 4-11 Mbps bandwidth and command-and-control of around 10-milli-sec. latency one way between radios. CURRE uses a high-power MIMO (multiple input, multiple output) radio with a steerable antenna that tracks the aircraft.

“We do not have line of sight when the helicopter drops down to deliver or retrieve the crate, so below the horizon it has to be autonomous,” says Fahrner. “It has to be able to see where to set down the crate and return to pick it up.”

CURRE will use the lidar-based autonomy system developed by Aurora Flight Sciences under the Office of Naval Research’s Autonomous Aerial Cargo/Utility System (AACUS) program. The full demonstration planned for 2019 is to use the autonomy-enabled AEH-1 helicopter developed for AACUS.

Phase 1 of the CURRE project ran from October 2016 to April 2017 and involved developing the concept of operations and of ground testing the communications integration. C2 and video links were used to drive the robot from a distance of 2 mi., the first time that had been done, he says.

Aurora’s autonomy-enabled, optionally pilot-ed AEH-1 will be used for the CURRE demo in 2019.

Phase 2a runs to June and has involved developing the smart crate and flight-testing communications. In November 2017, at the University of Maryland’s UAS test range, a Talon 240G small unmanned aircraft circling at 6,000 ft. was used to relay the 2.4-GHz video and 900-MHz C2 links to and from the robot.

The Phase 2b test in June will use a larger Navmar Tigershark to enable a robot controller at Indian Head to operate a robot at Webster Field, 50 mi. away. “We will use the smart crate and the directional antenna to get to 50 mi. and see what latency and bandwidth we get,” says Fahrner.

The Phase 3 demo planned for May 2019 will use the AACUS AEH-1 to deploy and recover the crate and robot. The demo is to be conducted at Patuxent River and will not involve a 50-mi. distance but will focus on proving the concept and the communications architecture. “We are not fully funded yet, but we are working on it,” says Fahrner.

Other potential uses of the CURRE concept include responding to chemical, nuclear and natural disasters by air-transporting unmanned ground vehicles or multiple unmanned aircraft to locations where they can be operated in conditions too dangerous for human responders.

Transition targets for CURRE include the Navy’s Bell 407-based Northrop Grumman MQ-8C Fire Scout unmanned helicopter. This can carry about 750 lb. externally, and its electro-optical/infrared sensor can be used for landing-zone selection as well as potentially to provide route data to the robot. Another target is the Navy’s planned Future Cargo UAS, which will have greater capability, says Fahrner.

The robot is to be supplied by the Navy’s Advanced EOD Robotic System (Aeodrs) program, which is developing a modular family from a backpackable 35-lb. robot to a 750-lb. trailer-transparent vehicle. CURRE is being designed around the midsize, 164-lb. Increment 2 Aeodrs, says O’Toole.

The crate carrying the robot is a version of the Pentagon’s Joint Modular Intermodal Container, which weighs 285 lb. and is already flight-certified. This is being modified into a “smart crate,” equipped with sensors and computers to locate the robot and automatically maneuver it into and out of the crate. # AviationWeek.com/awst
Low-Altitude Cargo Flights Could Be Autogyro’s Renaissance

*DLR TEAM HAS FLOWN SCALE MODEL OF AIR CARGO GYROCOPTER*

*TEAM WILL PROVE THE CONCEPT WITH REMOTELY PILOTTED MODIFIED AUTOGYRO GMBH’S 450-KG DEMONSTRATOR*

Tony Osborne

While popular in general aviation as a low-cost and fun form of flight, the autogyro has never really made it big in the commercial world.

Thousands of home- and factory-built machines are in private use, and a handful have even found their way into the hands of law-enforcement agencies. Qatar even uses some for limited search-and-rescue missions.

But a team of engineers from the German Aerospace Center (DLR) believe the gyrocopter’s attributes may have the makings of the perfect automated aerial delivery system. Since 2016, they have been exploring the potential of different aircraft configurations that could enable a certifiable, safe and low-cost system for commercial and humanitarian use.

“As well as looking at the flight system, we also had to look at what would be the most cost-effective approach to this problem,” Johann Dauer, one of the engineers on DLR’s Automated Low-Altitude Air Delivery (Aladdy) project, told Aviation Week at the ILA Air Show here.

The team studied high-wing monoplanes and box-wing fixed-wing aircraft, as well as conventional and unconventional helicopters, before settling on the autogyro. It was found to have many of the characteristics the team was looking for, including a low cost of operation and short takeoff and landing distances. Noise was also a factor, as Aladdy’s operation demands flights at low altitudes of 500-1,000 ft., although it will generally avoid built-up urban and other restricted areas by using geofencing.

While the fixed-wing configurations by comparison had a relatively low operating cost, they could not take off and land at anything like the short distances of the autogyro. And the helicopter has the advantage of being able to operate from anywhere but its complexity and high cost of operation make it unaffordable.

In simple terms, an autogyro is kept in the air by the lift from its freely autorotating main rotor. The airflow to keep the main rotor moving is a result of the forward speed provided by an engine-driven propeller, usually a pusher prop on most gyrocopter models.

The autogyro also brings with it several safety benefits, says Falk Sachs, an engineer with the flight dynamics and simulation department of the DLR Institute of Flight Systems and a gyrocopter pilot.

“When in the event of a loss of control, it is easy to predict where the aircraft will end up,” notes Sachs. Even in the event of a power loss, autogyros can autorotate down to a hard but survivable landing. The ability to safely terminate a flight is one of the key objectives for the project. To prove the point, the team has built a flying scale model of a cargo-carrying gyrocopter, which first flew this April.

The 45-kg (99-lb.) Air Cargo Gyrocopter (ACG) features two engines mounted on a small wing that straddles the cargo compartment, which can be loaded from the nose. The small wing provides extra lift and incorporates the fixed main landing gear. The purpose of the testbed has been to prove the machine’s flying characteristics.

The next step will be to fly the Air Dolly, a second much larger demonstrator based on an AutoGyro GmbH 450-kg MTOfree. The Air Dolly—a play on its function as a low-cost flying trolley—will demonstrate the carriage-of-cargo concept. The team has modified it with a flight-control system and a cargo container that allows it to transport about 150 kg of payload. Initial flight testing of the Air Dolly, due to get underway in the coming weeks, will be performed by remote control, before introducing more advanced automated functions such as taking off, cruising, landing and taxiing.

The team will also explore the ACG’s integration into the logistics chain and examine automated surveillance of the system, keeping the ACG away from other low-flying aircraft such as helicopters.

The team’s ultimate vision is a scaled-up ACG with a maximum take-off weight of about 2.6 metric tons that can carry up to 1 ton of cargo. Sachs says such an aircraft could use a distributed-power system with an engine positioned in the lower fuselage for two electric motors to drive the propellers. In a video produced by the team, the ACG’s fueling, cargo loading and even preflight inspection is shown as entirely automated, with another small drone inspecting the aircraft prior to departure. Inside, an automated tension system holds the cargo securely in place.

Operational ACGs could perform urgent, just-in-time deliveries from warehouses to customers or to support remote communities. And in the event of a natural disaster, they could deliver aid to areas by landing on roads or austere strips, Dauer suggests.
Falcon 9, Take 5

ROCKET MEANT TO FLY 10-12 TIMES WITH MINIMAL REFURBISHMENT

FIRST FALCON 9 BLOCK 5 TO LAUNCH BANGABANDHU SATELLITE-1 INTO ORBIT IN EARLY MAY

Irene Klotz Cape Canaveral

After eight years and 53 flights, SpaceX is preparing to debut what it expects to be the final configuration of its Falcon 9 rocket, a booster designed not only to increase the flight rate but launch astronauts to the International Space Station for NASA and deliver GPS and other payloads into orbit under competitively awarded U.S. Air Force contracts.

With the integration of Falcon 9 Block 5 into the fleet, SpaceX aspires to operate a more airline-type space transportation service, with minimal refurbishment of boosters between flights and building toward 30 to 40 missions per year. “Hopefully, in a year or two, the whole concept of reuse is not even a discussion. We don’t talk about airplanes being reused or how many flights they have seen before you get on an airplane,” says SpaceX President and Chief Operating Officer Gwynne Shotwell. “If you leverage the airline business model, that is where we are headed—complete and rapid reuse.”

It was just over a year ago that SpaceX launched a previously flown Falcon first stage for the first time, sending the SES-10 communications satellite into orbit aboard a booster that flew in April 2016 on an International Space Station (ISS) cargo resupply flight for NASA. Since then, SpaceX has reflown rockets 10 times, including a pair of first stages that served as strap-on boosters for the debut flight of the triple-core Falcon Heavy in February. So far, no booster has made a third flight.

SpaceX intends to change that paradigm with Block 5, which is slated to launch for the first time in early May on a mission for the Bangladesh Telecommunication Regulatory Commission. Bangabandhu Satellite-1, built by Thales Alenia Space, will be the first Bangladeshi geostationary spacecraft, providing broadcasting, telecommunications services and the first direct-to-home television programming in Bangladesh and the region. A cubesat, built by Bangladeshi university students, was launched in June 2017.

“Block 5 is designed for 10 or more flights with very limited refurbishment.
but should be capable of additional flights with further testing and possible additional refurbishment,” says Shotwell. “It is the final substantial upgrade to the Falcon 9 design, although we may make minor upgrades as we continue to strive for rapid reusability and extremely high reliability.”

The ultimate goal is to be capable of relaunching a booster within 24 hr. “That does not mean we want to fly the rocket once a day, but we could if need be,” Shotwell adds.

The booster is designed to meet or exceed the reliability and safety requirements for NASA Commercial Crew flights, expected to begin in 2019, as well as the U.S. Air Force’s Evolved Expendable Launch Vehicle (EELV) program, aimed at certifying two new, all-American-built orbital space transportation systems for flights beginning in 2022. SpaceX is among four companies vying for next-generation EELV Launch Service Agreement development contracts. Up to three contracts are expected to be awarded in July.

NASA intends to put Block 5 boosters into service as early as August, with the launch of SpaceX’s new crewed Dragon capsule on an unmanned test flight. In an April 19 speech at the 34th Space Symposium in Colorado Springs, Shotwell said hardware for a follow-on crewed test flight with two NASA astronauts will be ready by year-end, but she stopped short of committing to the mission in December, as is currently scheduled.

NASA says it will require seven successful flights of the Block 5 in a configuration similar to what is intended for use of the crewed test flight before it clears the booster to carry astronauts.

Some Block 5 upgrades, such as titanium grid fins used to help steer the booster for landing, improved thermal protection tiles and a new second-stage anti-vortex device, designed to prevent the formation of a vortex as long as possible to minimize propellant loss, were rolled out on current versions of the rocket, known as Falcon 9 Full Thrust.

The new Block 5 also includes a revamped octaweb, the metal structure that supports eight Merlin engines in a circle around a ninth, center engine at the base of the booster. Instead of welded aluminum, the octaweb will now be a bolted structure, a design change that greatly reduces the manufacturing and inspection burden, increases reliability and shortens the lead time for production. “We’ve also made improvements to the landing legs to support rapid post-landing vehicle processing and have upgraded the operational capability of components across the board,” Shotwell says.

As part of the Block 5 upgrade, and in partnership with NASA and the U.S. Air Force, SpaceX redesigned the Composite Overwrap Pressure Vessels (COPV), which are part of the rocket’s helium pressurization system. The upgrade includes “qualification of components, such as valves, to meet or exceed program standards,” Shotwell says.

The redesign stems from a Sept. 1, 2016, accident at Cape Canaveral AFS Space Launch Complex 40 when a COPV inside the second-stage liquid-oxygen tank burst during preparations for a routine prelaunch static engine test. The accident triggered an explosion and fire that destroyed the rocket and its payload—the $200 million Amos-6 satellite owned by Israel’s Spacecom—and heavily damaged what had been SpaceX’s only East Coast launch site at the time.

Later testing showed that the densified liquid oxygen SpaceX uses can
become trapped in buckles between the aluminum liner and the carbon overwrap of a COPV, causing fibers in the overwrap to break, or generating friction that can ignite the material. “Block 5, which has enhanced-reliability features and is optimized for rapid reusability and multiple reflights, was designed to meet the needs of all of our customers—commercial and the U.S. government,” says Shotwell.

Block 5 also incorporates design modifications to eliminate microfractures in the rocket’s turbopumps, which the Government Accountability Office last year flagged as a potential safety concern for NASA. Ground tests of SpaceX’s Merlin engines in 2015 showed cracks in two parts of the turbine wheels. SpaceX initially addressed the problem with a software fix and then redesigned the turbine wheels to avoid the cracks altogether. A second set of cracks in welds and shrouds were not considered a concern for flight, but NASA and the Air Force asked for a redesign, Shotwell says.

“For us, the concern was not the cracks, but do they grow over time? Would these cracks cause a flight failure?” she said in a 2017 interview. “I think NASA is used to engines that are not quite as robust, so they just don’t want any cracks at all in the turbo machinery.”

“Block 5 basically summarizes all that we learned on reusability,” notes Hans Koenigsmann, SpaceX vice president of build and flight reliability. “Whenever we recover a booster and then it goes through a refurbishment, we find things that are giving us lessons for the next block. In this case, we tried to summarize all of these lessons learned into a booster that is then able to fly and be recovered and fly again multiple times without a lot of refurbishment. That is basically the key thing on Block 5—it’s a reliability update that combines reliability and reusability.”

Shotwell declines to say how many Block 5 boosters SpaceX will manufacture, except that the company plans “a sizable fleet.” Beginning with the Bangabandhu Sat-1 launch, the only new rockets SpaceX will be flying will be Block 5s. The company intends to launch a mix of previously flown Falcon 9 Full Thrust vehicles and its new Block 5s throughout the rest of 2018. “Block 5,” Shotwell says, “will be SpaceX’s workhorse vehicle for years to come.”

The United Arab Emirates’ (UAE) space exploration program, now four years in the making, is an investment in the nation’s future that is beginning to produce results, says government officials at the Global Aerospace Summit here.

Not only is the UAE’s drive to explore space inspiring a new generation to pursue the study of science and math—it is also a matter of increasing political stability and, if all goes well, could seed discoveries that could help future generations of Emirates, says Ahmad Belhoul Al Falasi, chairman of the UAE Space Agency.

The UAE is surrounded by war and has many young people who might be tempted to emigrate. “We want to show if you focus on tolerance, if you focus on science, it can go a long way,” Al Falasi says. “Being tolerant and focusing on science is the right way, as opposed to extremism.”

To work toward that end, the UAE has crafted a 100-year plan for space that includes: training a corps of astronauts, sending the robotic Hope probe to Mars by 2021, becoming the first Arab country to manufacture satellites and sending humans to Mars by 2117.

The UAE recently closed its process for seeking astronauts, drawing 4,000 applicants, including one family of father, son and grandson. The candidate pool is about one-third female. “We really can see how inspiring it is,” says Al Falasi, also the minister of state for higher education and advanced skills.

He has already seen an increase in interest among young Emirates in studying engineering and science. “We used to send about 30% to study engineering in the States. And that jumped to 41% in just one year,” Al Falasi says.

A more educated workforce can help the UAE develop the technologies it needs to get to Mars. But the global policy shift to pursue a Moon landing as a steppingstone for Mars has been helpful to countries such as the UAE, because it allows them to start small and build, he adds.

Shooting for the Moon has also enabled the program to pursue development of niche technologies, Al Falasi says. The UAE expects to contribute ideas about water and energy conservation, two concepts the oil-rich desert nation is very familiar with.

Its first step in that direction is the UAE’s Hope mission, which would launch in 2020 on a Japanese Mitsubishi Heavy Industries H-IIA launch vehicle to arrive at the red planet by 2021. The 1,500-kg (3,300-lb.) spacecraft will be built with an aluminum honeycomb structure and composite surface. It will carry a high-resolution digital camera, an infrared spectrometer to study temperature, ice, water vapor and dust in
the atmosphere and an ultraviolet spectrometer to look at the upper atmosphere.

In addition to exploring the Martian climate, the UAE is building on and adding to projects dealing with renewable energy. One of them, Masdar City, is an entire neighborhood that uses advanced technologies to produce highly efficient renewable energy. “In Masdar City, 100% of water is being recycled,” says Al Falasi, who formerly led Masdar.

That is an important lesson to bring to space, where it can cost $10,000 to produce a liter of recycled water, he says.

Sustainable energy and resources will receive further study at a 1.9 million-ft.² (177,000-m²), $150 million Mars Science City simulation center in the works in the UAE. The center is in part both a museum and collection of specialized laboratories, including one for conducting 0g experiments. It will simulate life on the Martian surface.

The technologies developed at Science City will not only help in space, they will also have real-world applications. “Technology for exploration will come back on the ground and support people in the UAE,” says Salem Humaid Al Marri, of the Mohammed Bin Rashid Space Center.

The UAE’s exploration efforts are also adding steam to its existing space program, which includes telecommunications and remote-sensing satellites. It has developed KhalifaSat (formerly DubaiSat-3), the nation’s third Earth-observation satellite and the first manufactured in the UAE. It is scheduled to launch this year, also on a Japanese H-IIA rocket. The 330-kg spacecraft will monitor the Earth from an altitude of about 500 km (312 mi.).

The images will be delivered at 1-m resolution in panchromatic bands and 4-m resolution in multispectral bands.

And the company Yahsat recently acquired a majority stake in the well-known mobile satellite communications company Thuraya. The latter’s two satellites are joining Yahsat’s for a total of five that operate in the C, Ka, Ku and L-bands. In January, Yahsat launched the Al Yah 3 Ka-band satellite—the first hybrid-electric propulsion GeoStar-3 satellite made by Orbital ATK—which is expected to begin delivering high-speed connectivity to Africa and Brazil later this year.

The UAE is building its first Earth-observation satellite, KhalifaSat, to provide high-resolution imagery to help it study infrastructure and the environment.
ONWARD AND UPWARD

As SpaceShipTwo VSS Unity coasted to a new record apogee of more than 84,200 ft. over California on its first powered flight on April 5, the moment signified new heights not only for Virgin Galactic but also for the vehicle’s builder, The Spaceship Co. (TSC).

Far beneath the arrow-straight exhaust plume that marked the first successful airborne ignition of a TSC-built hybrid rocket in a TSC-made suborbital spacecraft, employees of both Virgin companies stood on the flight line at the Mojave Air and Space Port and cheered the completion of a huge step on the path toward final development of a Mach 3 vehicle for the fare-paying public.

While both organizations acknowledge the road has been far tougher and longer than anyone could have guessed, the prolonged gestation of Virgin Galactic—now marking its 14th year—has had a more enduring effect. Almost four years after the fatal 2014 flight-test loss of prototype SpaceShipTwo (SS2) “Enterprise,” the venture finally is on the verge of reaching space with a more robust, safer vehicle.

TSC, which was developed from the ground up as the vertically integrated production arm of sister company Virgin Galactic, is meanwhile deep into the assembly of two more spaceships and has, by necessity, matured into a sophis-
Virgin Galactic pilots Mark “Forger” Stucky and David Mackay reported a smooth ignition and initial acceleration during the first powered flight, VP-01.

ticated design, test and manufacturing organization. As a result, Virgin sees a broader role for TSC beyond spaceships, which ultimately could lead to development of high-speed, intercontinental passenger aircraft and other air and ground transport concepts.

To reflect this potential role, TSC has been rebranded with a stylized “maker’s mark” logo based on the thumbprint of founder Richard Branson which Virgin says, underscores a shift from specialist space work under its original iris-based logo to a company with broader aerospace and transport engineering and design capabilities.

TSC is “coming of age,” says the company’s president, Enrico Palermo. “We have greater street credibility now that we have flown a powered flight. Our new logo articulates the new sophistication of the company as we continue to build spaceships and start to work on future projects that are not space-related but [have] to do with transportation.”

Palermo, who was the first employee at TSC, whose workforce now numbers 478, says the expansion has come with experience. “We were set up as a sort of cost center to start with, and our job was to build spaceships and Virgin would launch them,” he explains. “But having done the last few spaceships, we have developed end-to-end capabilities, from preliminary vehicle design to post-flight servicing, and it would be a mighty shame not to leverage that capability and do other things which we know we can do. No one else, as far as we know, is working on building and testing a fleet of rocket-powered spacecraft. We’re it. And we are doing it not just for research and development but for commercial operations.”

For now, TSC’s priority is completing assembly of SS2’s Nos. 3 and 4 this year to support the long-awaited beginning of commercial flights from Virgin Galactic’s initial operational spaceline base at Spaceport America in New Mexico. First to enter service will be VSS Unity, the second SS2 built, and the first to be assembled by TSC. The first SS2, Enterprise, was built in the late 2000s by Scaled Composites, along with the WK2 carrier aircraft before Virgin acquired the specialist development company’s 30% stake in TSC in 2012.

While VSS Unity was produced and assembled in 2015 in much the same manner as Enterprise, the process has been altered radically for the first pair of “production-standard” spaceships. “Our big focus on these next two spaceships has been design for manufacturability, assembly, maintainability and performance,” says Palermo. “It is important we make them efficient to build, so we’ve made a lot of design changes. It’s not that on VSS Unity or Enterprise that the design is inadequate; it is more about making them easier to manufacture.

“As can be expected on a first build, many lessons were learned on the build of VSS Unity that we are rolling into the next spaceships’ design,” Palermo notes. “Through these design improvements, we expect to save several hundred pounds compared to VSS Unity, and we expect some of this weight optimization to flush back into the VSS Unity design eventually.”

As the program’s experimental flight-test vehicle, VSS Unity incorpo-
rates additional mass for items such as test instrumentation, which will not be needed on the next two spaceships.

Informally named after Branson’s twin grandchildren, SS2-3 “Etta” and SS2-4 “Artie,” the two vehicles are in different stages of assembly in TSC’s two main Mojave facilities: Building 79 and the newer final assembly, integration and test hangar (FAITH). The cabin of SS2-4 was bonded in Building 79 in March while other subassemblies and parts continue to come together around it. Parts such as the crew station have been reengineered to become more integral with the forward cabin structure, eliminating several weeks of build time.

Assembly of SS2-3, which will be the second spaceship to enter service, is more advanced in FAITH, where TSC has invested “a lot of money,” it says, in two large fuselage assembly fixtures. “Unity and Enterprise were both built in one spot whereas with the next two, we are building them much more like you’d see an airliner come together,” says Palermo. Eight major subassemblies—including the fuselage, wings and feathering tail system—will be brought into FAITH, where “we snap it all together.”

Besides the almost complete basic cabin assembly for SS2-3, the lower and upper wing skins are being prepared for attachment to the spars. The closed-out cabin already incorporates much of the vehicle’s wiring, brake systems and pneumatics. “At this point, Unity’s systems weren’t installed,” Palermo says. “We did those afterward, whereas here the systems are also being assembled modularly with the wiring and black boxes being made here in our avionics lab.” TSC also is building a “copper bird” ground-test rig for all SS2 systems and electronic components. “We will build a replica on the ground before we integrate them into the vehicle because we are making some changes to the actuation system for weight and performance improvements,” Palermo says.

In another work cell in Building 79, work is underway to complete the torque tube at the heart of the spaceship. The 23-ft.-long composite structure runs transversely and forms the pivot point for the movable tail booms that deploy into a 60-deg. upward position for the vehicle’s “feathered” re-entry configuration. The single-piece unit, which also supports the flaps, was 46 days into a targeted 125-day build cycle when Aviation Week visited TSC in mid-April.

Although the torque-tube design reflects design changes to ease production, the pneumatically actuated feathering system itself remains unaltered. Changes have, however, been made to the control system to prevent inadvertent or premature unlocking of the type that led to the loss of the Enterprise. New safety features include a mechanical inhibit system consisting of a locking pin with a solenoid switch controlled by the flight-control computer, as well as an override device.

TSC also is building the second of three new aft spars, following a redesign. Two will be flight articles, while the third will be used as a structural test piece to verify changes, which, like the other components, are being made for ease of production.

“It was not the greatest experience building the first ones, from a tooling integrity perspective,” Palermo says. “It took us a few tries to get the one we used ready for flight, so as part of making it more manufacturable and enabling us to make the vehicle quicker, we’ve had to make design changes.”

Another redesigned element is the lower nose section, which, in the first SS2s, had to be cut open for installation of the landing skid and its housing. “We re-tooled and made it a single-part piece, which took 13 lb. out of the structure, eliminated a lot of structural bonds and saved several hundred hours of assembly work,” Palermo explains.

The machine shop area in the east end of Building 79 is dedicated to production of the hybrid rocket motor; assembly is currently running at two per month based on a single shift. “We are starting to work on how we productionize the rocket motor because, when we have three spaceships flying, we will need a lot of them,” he says.

Perfecting the rocket system, which is the only non-reusable element of the vehicle, has been the most challenging aspect of the suborbital spaceship project. Developed originally with Sierra Nevada, the engine is a scaled-up, 65,000-lb.-thrust version of the same rubber-based hydroxyl-terminated polybutadiene-fueled (HTPB) hybrid motor used in the original XPrize-winning SpaceShipOne. Despite briefly evaluating an alternate polyamide-based grain to boost thrust rates, the company is committed to the polybutadiene-based motor because of its demonstrated high manufacturing qualities.

Assembly of SS2-3, which will be the second spaceship to enter service, is more advanced in FAITH, where TSC has invested “a lot of money,” it says, in two large fuselage assembly fixtures. “Unity and Enterprise were both built in one spot whereas with the next two, we are building them much more like you’d see an airliner come together,” says Palermo. Eight major subassemblies—including the fuselage, wings and feathering tail system—will be brought into FAITH, where “we snap it all together.”

Besides the almost complete basic cabin assembly for SS2-3, the lower and upper wing skins are being prepared for attachment to the spars. The closed-out cabin already incorporates much of the vehicle’s wiring, brake systems and pneumatics. “At this point, Unity’s systems weren’t installed,” Palermo says. “We did those afterward, whereas here the systems are also being assembled modularly with the wiring and black boxes being made here in our avionics lab.” TSC also is building a “copper bird” ground-test rig for all SS2 systems and electronic components. “We will build a replica on the ground before we integrate them into the vehicle because we are making some changes to the actuation system for weight and performance improvements,” Palermo says.

In another work cell in Building 79, work is underway to complete the torque tube at the heart of the spaceship. The 23-ft.-long composite structure runs transversely and forms the pivot point for the movable tail booms that deploy into a 60-deg. upward position for the vehicle’s “feathered” re-entry configuration. The single-piece unit, which also supports the flaps, was 46 days into a targeted 125-day build cycle when Aviation Week visited TSC in mid-April.

Although the torque-tube design reflects design changes to ease production, the pneumatically actuated feathering system itself remains unaltered. Changes have, however, been made to the control system to prevent inadvertent or premature unlocking of the type that led to the loss of the Enterprise. New safety features include a mechanical inhibit system consisting of a locking pin with a solenoid switch controlled by the flight-control computer, as well as an override device.

TSC also is building the second of three new aft spars, following a redesign. Two will be flight articles, while the third will be used as a structural test piece to verify changes, which, like the other components, are being made for ease of production.

“It was not the greatest experience building the first ones, from a tooling integrity perspective,” Palermo says. “It took us a few tries to get the one we used ready for flight, so as part of making it more manufacturable and enabling us to make the vehicle quicker, we’ve had to make design changes.”

Another redesigned element is the lower nose section, which, in the first SS2s, had to be cut open for installation of the landing skid and its housing. “We re-tooled and made it a single-part piece, which took 13 lb. out of the structure, eliminated a lot of structural bonds and saved several hundred hours of assembly work,” Palermo explains.

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and propulsion consistency amid continuing development issues in 2014, Virgin reverted to the original fuel and brought all development in-house in May of that year.

The motor “is qualified to get us to space now,” Palermo reports. “We’ve fired it on the ground longer now that we anticipate flying, just to give us margin from a safety perspective. The minimum mission to which we have committed is the NASA definition of space [50 mi./81 km], and we have a motor that will get us there. The important thing is until we fly the full profile, we won’t know the exact performance, though we have very high confidence of hitting the NASA milestone.”

HTPB is poured from a central mixer into filament-wound cylinders in one of two core stands. The flow rates and grain mixture are controlled precisely and allowed to cure. However, with the prospect of producing hundreds of hybrid motors, TSC also sees the rocket line as providing an early opportunity to introduce automation. The company has acquired a KUKA robot as part of studies to automate trimming and pressing materials for making the filament-wound motor casings. “Automation could be used for the rocket motor but also eventually apply to other programs that will be done by TSC,” Palermo says.

Development, test and qualification of the hybrid motor has been accomplished using a recently constructed vertical test stand that sits over a 60-ft.-deep U-shaped flame tunnel. The rig augments the original horizontal test stand but better replicates the attitude of the motor when it is powering SS2 in its near-vertical climb. “With the horizontal stand, we couldn’t mimic all the characteristics and phases of flight, so to get a fair shot at it, we wanted to test downward,” says Dave Raibeck, TSC propulsion test and supervisory. Use of the vertical rig precludes needing a snorkel to scavenge the nitrous oxidizer that settles at the base of the motor in the horizontal position, affecting the rocket’s overall performance.

Motor improvements appear to be verified by results from the first powered flight, VP-01, during which pilots Mark “Forger” Stucky and David Mackay reported a smooth ignition and initial acceleration. “Initial data review results show that the TSC hybrid motor performed very well and to specification,” Palermo says.

However, while the 30-sec. rocket burn—which powered VSS Unity to Mach 1.87 and 84,271 ft.—expanded the flight envelope more than any other step in terms of motor-burn duration, Mach speed, apogee and loads, TSC says “a tremendous amount of data” still needs to be analyzed before the next procedures are determined.

“We are not going to go full duration on the next one, and it might even be a repeat of this one,” cautions Virgin Galactic CEO George Whitesides. “We are going to spend time testing the basic parameters of the vehicle, then get into envelope expansion and exploring different scenarios. In parallel, more to the later side, we also will do interiors testing to make sure the customer experience and the hardware associated with that does what we want it to do.”

The main test priorities are focused on structures, rocket engine burn time and handling qualities, Virgin Galactic President Mike Moses says. “As long as everything is going well, we just have to verify things with the structure, and it is the same thing with the burn time. So handling qualities [are] what we are down to and all the potential unknowns.” Envelope expansion will continue with various weight and center-of-gravity positions, many of which will be used to validate the model-based test program.

Virgin originally hoped to start powered flight tests in late 2017, but peer reviews of loads analysis on the structure of VSS Unity, which was beefed up in the redesign following the loss of the first SS2, took longer than expected. Although glide flights provided some insight into the airframe loads, these imposed less than 60% of the stresses imparted during powered flights. The highest structural loads occur as the rocket ignites and the vehicle begins its climbing, or gamma-turn, maneuver.

Future testing is planned to include deployment of the feathering reentry system at supersonic speed, which will require a rocket burn of 45-50 sec. Full-endurance flights, in which the hybrid motor will fire for up to 62 sec., will follow, with tests of handling qualities at rocket burnout as well as those of the thermal environment in suborbit.

Check 6 Aviation Week editors discuss prospects for sending humans to suborbital space this year: AviationWeek.com/podcast.
LauncherOne, a two-stage, air-launched rocket in development by Virgin Orbit, is not aiming to break records for highest thrust, performance or lift capacity. Instead, Virgin Orbit, a sister company to the nearby Mojave, California-based Virgin Galactic, has developed a simple booster, fueled by liquid oxygen and kerosene, designed for quick, consistent fabrication and reliable flight to orbits up to about 750 mi. (1,200 km) above Earth, depending on payload mass, launch latitude and launch azimuth.

“It’s about as simple a rocket as we could get,” says Vice President Will Pomerantz. “We’re optimizing for a highly affordable, highly flexible launch vehicle.”

Toward that end, each stage is powered by a single motor. Qualification tests of the Newton Four (N4) upper-stage rocket engine are underway, while similar testing for the first-stage N3 is due to start by the end of May, marking a key step toward the first test flight to space later this year.

The transition to qualification tests means Virgin Orbit has effectively completed development of LauncherOne’s rocket motors, with a series of full-duration runs of the 73,500-lb.-thrust-rated N3 and 5,000-lb.-vacuum-thrust-rated N4 at its Mojave test facility. “We have a few more development tests to run [on N3], then we will get to first-stage qualification,” says CEO Dan Hart. “We put a nice full mission duration on the first stage [on April 17] and have been testing restarts on the second stage.”

The full-duration target for the N3, which includes cycling of its gimballing system, is around 180 sec., while the N4, designed to make multiple burns or a single full-duration burn, has been run to its planned full-duration burn of 360 sec.

Although development tests uncovered “lots of little squawks,” Pomerantz says the company is quite confident about the design. “On the engine specifically, we are not done, and we are never done, but we have [finished] all the riskiest things. Now it’s a matter of doing them all every time. It is all about full thrust, with a flight-like configuration, gimballing with the right ignition sequence—then turning the crank on it and having it work the same way over and over again,” he says.

Virgin Orbit’s hybrid manufacturing machine can produce multimetallic parts that seamlessly transition between two different metals, such as this copper-nickel subscale test chamber.

Virgin Orbit plans to launch at least twice this year, beginning with a company-sponsored test flight followed quickly by the first commercial flight. By 2020, the company intends to ramp up to 24 flights per year. So far, it has sold about 30 missions, Hart says.

Supporting that flight rate spurred Virgin Orbit to seek out and adopt manufacturing processes and personnel from other industries. LauncherOne’s avionics boxes, for example, are about the size of an iPad—compared to traditional designs, which are about the size of a desktop computer tower. The company owns a large-scale, hybrid additive and subtractive machine that can manufacture from any type of metal. “We can dramatically reduce the part count,” says Pomerantz. “The manifold of the engine, for example, traditionally is a 30-part assembly. We can print it as a single part.”

Besides cutting engine manufacturing and assembly time from about 10 months to one, the reduced part count should yield a more reliable, less expensive launch system. “The more things we can build in one part instead of 30, the cheaper it is for us, and we can pass those savings along,” Pomerantz says.

The new manufacturing techniques are also spurring ideas for alternative designs. “We have a part of the second stage that is literally called the HPEM—the hardest part ever made,” says Hart. “Somebody using additive manufacturing to shrink the number of parts tremendously came up with an incredibly innovative design. . . . We started from the standpoint of building things better than we design in a traditional way. Now there is a new generation that grew up on additive manufacturing, and they are rethinking what to design.”
Europe Accelerates Studies on Reusable Launchers

> IT IS A MATTER OF WHEN, NOT IF, SAY EUROPEAN SPACE PUNDITS

**Thierry Dubois Paris**

It is 5:00 p.m. local time on July 15, 2030, in Kourou, French Guiana, and the final countdown is underway for Ariane Next, Europe's first reusable launcher. The last decade has brought an accelerated evolution of the launchers built by ArianeGroup under the leadership of the European Space Agency (ESA). Ariane 6 had a relatively brief career—almost three times shorter than its predecessor.

Rewind to 2018. The launch of SpaceX's Falcon Heavy, although it was of limited significance on the satellite launch market, was the watershed event. Before it, European players were content with reusability demonstration programs just like any other research and technology activity. After it, the debate moved to “when” from “if.” For the second time in four years, ArianeGroup, ESA and state agencies made a move in reaction to Space X's prowess in reusable launchers.

In 2016 and 2017, the most common stance in the European industry was doubt. “Is there a business case for reusing a launcher?” was a question heard many times. Experts were pointing out that building one reusable launcher per year may not make sense. The vehicle would be in the realm of prototypes, “with associated uncompetitive costs and risks in quality.” ArianeGroup CEO Alain Charmeau said as recently as December 2017 that reusability was “probably the technology of 2050, when it will be mature and with a greater launch rate.”

A clear signal came this month, during the annual press conference of GIFAS, the French aerospace industry's lobbying association. “Reusing the booster [the launcher’s first stage], that’s for tomorrow, not the day after tomorrow,” Chairman Eric Trappier said April 12.

But the first indications of a change of heart came just after the near-perfect execution of the Falcon Heavy’s mission on Feb. 6. Five days later, ESA Director General Jan Woerner wrote on his ESA blog, “The world has moved on and . . . requires that we reassess the situation.” He was referring to the 2014 decision of ESA ministers to develop a new launcher family comprising the single-use Ariane 6 and Vega C.

“At that time, I succeeded in placing . . . the possible development of reusability among the high-level requirements,” he added. “Due to time and cost pressure, however, these aspects did not make it onto the agenda for Ariane 6 and Vega C.” Woerner soon posted a second blog entry asserting that the 2014 decision “was the right choice.” But for the long term, he did not change his opinion that “the kind of approaches seen so far would . . . fail to convince.”

On March 2, Jean-Marie Astorg, head of launchers at French space agency CNES, soon concurred (he later declined an interview with Aviation Week). “Let’s go for it!” he stated in a CNES publication. “Elon Musk must be credited for having shown [first-stage reusability] is technically feasible, and he is about to demonstrate the business case.”

The possibility of a reusable version of Ariane 6, before Ariane Next, also emerged. CNES has demonstration programs in reusability, and Astorg said, “We will see whether this technology will be applied to Ariane 6 or, later, to Ariane Next.” Arianespace CEO Stephane Israel, who is also executive vice president of ArianeGroup, in charge of civil launcher programs, agrees. “We have to look at all the evolutions possible for the Ariane; reusability is one,” he told Aviation Week in March.

Again, that was a departure from earlier statements. In December 2017, Charmeau suggested a new version of Ariane 6, around 2030, may benefit from an engine developed for a reusable launcher. On Ariane 6, it would not be reused but would bring lower costs, he said at the time.

For the Prometheus engine demonstrator, ArianeGroup and its partners target a unit cost of about $1 million ($1.2 million), or 10 times less than the cost of producing existing engines such as the Vulcain 2. Tests are scheduled to start in 2020.

It is safe to say that ESA will soon endorse studies conducted at the national level. CNES is collaborating with Germany's DLR and Japan's JAXA on designing a launcher demonstrator planned to fly late in 2020, called Callisto, an acronym for “Cooperative Action Leading to Launcher Innovation in Stage Toss-back Operations.” It will be 15-m (50-ft.) high with a 1-m diameter, powered by a cryogenic liquid oxygen and hydrogen engine and will feature four deployable ailerons at its top. Toss-back will be executed at an altitude of 50 km (31 mi.). The engine will be reignited at an altitude of 1 km for a soft landing.

Callisto will be used “to acquire a good command of the complex return of a launcher, the requalification operations between two flights and to put a precise number on the cost of an operational launcher with a reusable first stage,” Christophe Bonnal, an expert at the CNES launcher Directorate, said early this month.

In 2025, Themis—a demonstrator 10 times larger than Callisto—may use the Prometheus engine.

The European industry sees reusability as a way to halve Ariane 6’s costs, which remains the ultimate goal. ☛
Italy’s challenging economic climate is perhaps not the most conducive for evolving an air force, yet the nation is now taking deliveries of F-35 Joint Strike Fighters (JSF), maritime patrol aircraft, jet trainers and new intelligence-gathering assets. Aviation Week London Bureau Chief Tony Osborne caught up with the Italian Air Force commander, Enzo Vecchiarelli, to find out how this evolution is gaining pace.

**AW&ST:** What will the F-35 bring to the Italian Air Force? The F-35 is the aircraft suitable and necessary for new-generation scenarios. It is not just a fighter but also the best asset that can be used in a growing number of hybrid situations to achieve information superiority.

It seems that the F-35 is not a popular program with Italian politicians. How do you convince them of the aircraft’s attributes? Our political leadership is aware of the importance of the JSF program and the tremendous enhancement this asset will bring to the capabilities of the defense ministry. Even when severe budget constraints forced a decrease in the number of acquisitions, Italy’s participation in the program has never been in doubt.

**AW&ST:** When do you hope to declare the F-35 operational? We are on track to achieve initial operational capability (IOC) by the end of 2018. IOC depends upon several parameters. These include the appropriate number of aircraft being delivered to the operational units, the proper level of training and expertise for personnel and the software block upgrade that will enable us to employ the appropriate weapons for the assigned missions.

**AW&ST:** You are planning to host the first fifth-generation Tactical Leadership Program (TLP) exercise at Amendola AB [to train NATO aircrews how to work better in a coalition operation]. Are other F-35 nations interested in the exercise? Because Amendola is the first European F-35 operational base, it is fully up to speed to host fifth-generation assets for deployment, exercises and real operations. Therefore, we have offered our partner nations the chance to perform the fourth 2018 TLP course over our territory. This represents the first opportunity in Europe to host training activities involving the F-35, fostering interoperability between fourth- and fifth-generation assets during complex and advanced missions. All the TLP-signing nations have shown great interest; there is an initial bidding to take part in the course for approximately 50 aircraft.

**AW&ST:** With four fighter types in the current inventory, what are the current plans for the various fleets? The Panavia Tornado and AMX will continue to be responsible for air-to-ground and reconnaissance missions for a few more years because they are able to cover several roles and operational scenarios, thanks to their ability to interoperable with coalition assets. The AMX will be phased out within the next three years and the Tornado in the late 2020s. Ultimately, the F-35 and F-2000 (Eurofighter) assets will
cover the wide spectrum of our operational roles, from information superiority to kinetic capability.

Will the Typhoon receive an air-to-ground role? The Italian Air Force will soon achieve an operational capability in the air-to-ground role. This step forward will enable us to better manage the transition between third-generation assets (the Tornado and AMX) and fifth-generation (fighters). When this transition process is completed, we will have two completely interoperable assets—the F-35 and F-2000—allowing us to cover and manage the full spectrum of challenging combat scenarios by choosing the best combination for any given operation.

What part does the AMX still play? As a cheap, robust and easily deployable asset for counterinsurgency, is it almost unique in Western Europe? The AMX has been demonstrating its value for years. The mid-life-upgrade version, ACOL (Italian for Operational and Logistics Capacity Update), has been employed in Afghanistan, Libya and Iraq, where it has provided intelligence, surveillance and reconnaissance (ISR) and air-to-ground support. It has proved to be capable, precise, reliable and affordable. We have therefore decided to extend its operational life until 2021, given the prolonged acquisition phase for the F-35 fleet.

What is your take on the future European fighter aircraft that France and Germany are contemplating building? We are following with interest the possible Franco-German joint venture to build a fifth- or sixth-generation fighter. For sure, the challenges will be extreme, but it could be a tremendous stimulus for the European aircraft industry. It will also be a long process involving several years and many resources. We need to think about fleet replacement, so a future European solution is definitely of interest.

What are the next steps in the Italian unmanned air vehicle (UAV)/unmanned combat air vehicle (UCAV) plan? UAV systems are an extremely valuable asset of our airborne ISR enterprise. They contribute daily to build up and consolidate the information superiority required for modern scenarios.

We have several years’ experience with the Predator A and B, which has allowed our air force to take a leading role in Europe in processing, fusing and disseminating the information from multiple ISR platforms—including the F-35. For the future, the air force is collaborating with Piaggio on the P2HH project and with other European partners for development of the next-generation medium-altitude long-endurance Strategic class UAV.

What are your plans with the new airborne early-warning Gulfstreams? Since Italy is already part of the NATO E-3 component, what role do these new Gulfstreams play? The CAEW (Conformal Airborne Early Warning) aircraft is a multisensor system able to address aerial surveillance as well as command, control and communications needs. These are fundamental in contributing to air supremacy and battle management. We plan an early-warning and command-and-control role for this asset, since it can be airborne with shorter tasking and employment times compared to the multinational AWACS.

It is indispensable for national airspace surveillance, although it may help support NATO/EU or coalition needs.

Many air forces are facing personnel retention and pilot shortages. Is this the same for Italy, and if so, how are you combating the situation? Pilot shortage seems to be widespread across many air forces, and we are not immune. So far, our selection process and in-house training capabilities allow us to retain an acceptable ratio between the fielding of newly trained pilots and the replacement of experienced ones who reach the end of their flying duties. The biggest challenge now is the need to train pilots for the new F-35 operational squadrons while maintaining operational capabilities on the other fighter components. We’re focusing on an efficient training system that shortens F-35 training time while allowing pilots to quickly come up to speed with the operational environments and complexity of the new information-management systems on the aircraft.

Alessandro Profumo, CEO of Leonardo, says his company wants to work more closely with the Italian Air Force on training and expanding the number of countries wanting to train in Italy. Can you provide more details? Our jet pilot training school, based at Lecce AB, home of the 61st Wing, comprises instructors and students from many nations as well as from NATO and other partners. The lead-in fighter training course, based on the new T-346 integrated training system, developed by Leonardo in close cooperation with us, is recognized worldwide. Such advanced training capabilities fit many partner countries’ requirements, and foreign personnel have been increasingly involved in our training base. We host nine exchange instructor pilots and dozens of foreign students. These commitments, which are expected to grow, are a tangible proof of the quality and appreciation of our flight training.

The Italian Air Force declared an initial operational capability for the F-35 in the air-to-air role at the beginning of March. A multirole IOC will come later in the year.
Australia Begins Upgrading Farseeing Radars

> HIGHER PRECISION IS SURELY PART OF PROJECT
> THE SYSTEM IS ALREADY BETTER THAN USUALLY UNDERSTOOD

Bradley Perrett Beijing

An upgrade of one of Australia’s three huge Jindalee over-the-horizon radars will become initially operational in one of the sensors in six years under a program started by BAE Systems on April 4. The company is applying undisclosed government-developed technology that Defense Minister Marise Payne says involves a significant redesign of Jindalee.

The work evidently includes increasing command-and-control integration, addressing obsolescence, reducing operating costs and, very probably, improving sensitivity and precision in detection. The sensors, already regarded as the world’s most advanced over-the-horizon radars, have considerable room for improvement, an industry source says, hinting at the degree of the upgrade.

The three radars, operated by the Royal Australian Air Force (RAAF), are located in the Outback, each more than 1,000 km (625 mi.) apart. They surveil the air and sea north and west of the continent at a range of at least 3,000 km. But they detect targets only imprecisely because of the inherent limits of their mode of operation, bouncing high-frequency radio energy off the unstable ionosphere.

“The upgrade of the first radar is scheduled to reach initial operating capability in early 2024,” prime contractor BAE tells Aviation Week. “Each of the three radars will be upgraded successively with the new increased capability.” Completion is due in 2028, says Payne.

The defense department says the A$1.2 billion ($920 million) upgrade is part of the previously discussed project Joint 2025 Phase 6—probably most of it, judging from BAE’s budget and the absence of public plans for further immediate work. The general objective is to operationalize technology from the government’s Defense Science and Technology Group (DST), says BAE. The subcontractors are Raytheon, Australian defense electronics specialist Daronmont Technologies and infrastructure engineering company RCR Tomlinson.

Lockheed Martin competed with BAE for the work. Announcing the choice of BAE on March 5, the government released scant specifics about what it was buying. But the defense department told Aviation Week in 2014 that the priority for Phase 6 would be dealing with obsolescence of components (AW&ST Sept. 22, 2014, p. 42). Formally called the Jindalee Operational Radar Network, the system has been in service since in 2003; full-scale development took 12 years.

But there is rather more to the upgrade than replacing equipment that can no longer be supported. The department also said in 2014 that Phase 6 would include varying the size of the patches of air and seaspace the radars successively observe. This must mean each upgraded Jindalee radar will be able to pour more radio energy into a smaller space to work on a difficult target, or spread its energy wider to keep an eye on easy targets over a greater area.

Steered electronically, the radars shift between patches as they work. How often is unknown, but the interval must depend on the difficulty of the targets and the condition of the ionosphere, which such radars use as a blurry, unstable mirror. The arrays are vast. For example, the receiving antenna of the Jindalee radar at Alice Springs is 2.8 km long.

“High frequency” is high only by the standards of the early 1940s, when radars were first able to generate such transmissions. But it works against stealth aircraft, which are designed to defeat higher frequencies.

The Jindalee upgrade almost certainly also includes integrating the network more tightly into the command-and-control systems of the RAFAE, and perhaps the Royal Australian Navy. Discussing upgrade plans stretching to the 2030s, the defense department said in 2016 that enhancements would “allow Jindalee to cue and be cued by other systems across the sensor network.”

It is already well-integrated. In 2016, Aviation Week was allowed to see Australia’s national tactical air picture at RAAF Williamtown, Newcastle, where the Boeing Vigilare system integrates tracks from a variety of military and civilian sensors. Among the tracks displayed on that day were some from Jindalee. (They were not far from the coast, so maximum range was not revealed.) A control center at RAAF Edinburgh near Adelaide operates the radars, processes the basically raw data it receives from them and distributes the tracks.

Other hints at the elements of the upgrade are in the content of a smaller, preparatory effort that preceded it. That included improving or developing radar performance-analysis tools, working on waveform generator and receiver technology for Phase 6, developing multichannel digital receivers that would reduce component count, improving ionosphere sounders and developing software tools suitable for long-term sustainment.

Though no one is saying so, improving sensitivity and precision is surely part of the upgrade; officials have said they would never stop trying to improve Jindalee’s performance, which has already been stepped up once, in an upgrade completed in 2018. For radars such as these, precision and sensitivity
depend in part on improving understanding of the condition of the ionosphere. Daronmont is involved there, since BAE says that upgrade involves work on the network of transponders and ionosondes, which are sounders that monitor the ionosphere.

Jindalee’s current precision for absolute target location is better than 50 km, says another source, an engineer who is familiar with the system but unwilling to give exact figures. “Absolute” location is that of the object relative to the Earth (and the radar). In this mode the system would have to cue some other wide-area sensor, such as an airborne-early-warning (AEW) aircraft, for gathering better data that could in turn cue the sensors of a weapon system.

But Jindalee, like other sensors, also locates targets relative to each other. For that, its precision can be better than 5 km, depending on ionospheric conditions, says the engineer. So if the system knows the absolute location of one target—such as a friendly or neutral aircraft or ship or a fixed object on the surface—it can determine the absolute location of another to within 5 km.

That means the system is operationally far more powerful than generally appreciated. A commanding officer could sometimes orchestrate an engagement without having to bring up an AEW aircraft—which might not be immediately available and could be vulnerable. Instead, fairly precise data from Jindalee could be used to directly bring a fighter’s radar onto a target.

The patches are called tiles. In their current, fixed sizes, they measure 600-700 km in range and 300-400 km in azimuth, says the source.

Targets are detected by Doppler; the tiny shift in frequency of the return signal caused by movement toward or away from the radar. A Jindalee radar may need to dwell on a tile for only 1 sec. to pick up an easy target, such as an aircraft flying straight on a course that is rapidly closing or opening the range. A somewhat difficult target may demand tens of seconds.

For a really difficult target, such as a rapidly maneuvering aircraft, continuous coverage could be needed. In that case, the radar could not watch other tiles. But the tile it would be dwelling on, maybe 200,000 km² in area, could cover many targets of interest. And Australia has three Jindalee radars.

BAE says it and its subcontractors will reach peak effort on the upgrade in the third year of the program, the fiscal year ending in June 2021. Raytheon will work on systems engineering and software development alongside BAE.

The defense department was unwilling to lose much Jindalee capability during the upgrade. “BAE Systems offered a high-confidence program designed to minimize the risk and assure the availability of the radars during the upgrade,” a company spokesperson says. “It proposed a number of key innovations that will improve capability and supportability of [the radar network] and reduce the total cost of ownership.”

Starting with the undisclosed technology developed by DST, BAE will design the necessary hardware for manufacture and supportability, implement the software on Jindalee’s open-architecture distributed data system and apply a support system concept that the company says guarantees reliability and availability.

The defense department was in the comfortable position of having two bidders that were each familiar with Jindalee from current work: BAE has been supporting the Alice Springs radar, in the center of the continent, while Lockheed Martin has been maintaining the ones at Longreach in the east and Laverton in the west. During all three. The government a new support contract.

BAE says its payment cost plus a fee. Most of ed at Adelaide, home of and electromagneto well as the system’s op-
U.S. Aims for Faster, Easier Exports of Military Unmanned Aircraft

CONVENTIONAL ARMS TRANSFER POLICY HELPS COMMERCIAL SALES

UNMANNED AIRCRAFT POLICY EASES RESTRICTIONS ON MORE CAPABLE SYSTEMS

Graham Warwick Washington

Frustrated at seeing “Chinese knockoffs” on the runways of U.S. allies in the Middle East, the Trump administration has released updated policies for the export of conventional weaponry, including unmanned aircraft, that it says will make sales of U.S. equipment easier and faster.

The new policies for conventional arms transfer (CAT) and unmanned aircraft system (UAS) exports will provide allies and partners “with greater access to U.S. arms and reduce their reliance on Chinese knockoffs” as well as Russian weapons, says Peter Navarro, director of the White House Office of Trade and Manufacturing Policy.

Both policies are intended to make it easier for U.S. companies to make direct commercial sales of arms and UAS to allies and partners. Direct commercial sales, rather than via the more expensive and time-consuming government-to-government Foreign Military Sales process, are expected to make U.S. companies more competitive with foreign rivals such as China.

The facsimiles against which Navarro fulminates are China’s CH-4 and Wing Loong medium-altitude, long-endurance unmanned aircraft, close equivalents to the General Atomics Predator and Reaper. Armed versions are operated by Saudi Arabia, the United Arab Emirates (UAE) and other traditional buyers of U.S. equipment in the Middle East.

The UAE requested Predators in 2013 and finally received unarmed export versions in 2017. But the sale of armed Reapers, to the UAE and Jordan, was blocked by the Obama administration. The UAE instead became the launch customer for China’s Reaper-class Wing Loong II armed UAS, with satellite imagery showing aircraft were deployed by late 2017.

Navarro says the Obama administration’s overly restrictive policy on UAS exports allowed foreign competitors to make sales to traditional buyers of U.S. equipment. The new export policy is aimed at enabling additional sales of Missile Technology Control Regime (MTCR) Category 1 UAS such as the Reaper by “allowing companies to go ahead with direct commercial sales to customers, rather than via the U.S. government,” says Ambassador Tina Kaidanow, principal deputy assistant secretary of the Bureau of Political-Military Affairs in the State Department.

In a key move to ease the export of UAS, the Trump administration has changed the way the sale of unmanned aircraft that are fitted with laser target designators is handled during the review process, she says. Previously, laser designators were considered “strike-enabling technology” and unmanned aircraft fitted with the systems were deemed to be equivalent to armed UAS and scrutinized the same way. “This has hampered sales,” says Kaidanow. The new policy eliminates special scrutiny of UAS with laser designators.

China’s Reaper-class Wing Loong II debuted at the Paris Air Show in 2017 as part of an aggressive sales campaign against U.S. systems.

The new U.S. policies do not change the “unconditional strong presumption of denial” for exports of Cat. 1 UAS under the multilateral MTCR guidelines, Kaidanow emphasizes, only how potential sales are reviewed within the U.S. government. Presumption of denial will be assessed against “other important factors” when U.S. sales undergo review, she says. The Trump administration still wants to update the MTCR to keep pace with changes in technology, but “that’s another issue,” she adds.

The new CAT policy, meanwhile, “explicitly inserts consideration of [U.S.] economic security” into the national-security review process for arms sales, says Kaidanow. The goal is to “create jobs and provide economic security for the U.S.” through increased exports. The policy also includes “strategic advocacy for industry to enable sales and help with things that make it harder to sell” U.S. equipment. “Strategic financing” assistance to offset the higher cost of U.S. arms will be a factor, she says.

The new policies also do not change the legal and regulatory requirements for U.S. arms exports, Kaidanow says, including notifying Congress in advance so it has the option to veto potential sales. “Congress is the ultimate authority and retains that role,” she says.

While welcomed by industry, analysts judge that the changes are not dramatic shifts from previous policy on arms sales. There are questions about how much more sales can increase, as the U.S. is already the largest exporter—its weapons deals increasing by 25%, to 34% of total arms exports in 2013-17, almost 60% higher than second-place Russia, according to the Stockholm International Peace Research Institute. China is the fifth-largest, although its exports rose 38% over the same period.

But the changes come as the U.S. faces greater competition, particularly for the sale of unmanned aircraft, and not just from Beijing. South Korea and Turkey substantially increased their respective arms exports in 2013-17, as did Israel. Both Seoul and Ankara are expected to seek international markets for their domestically developed armed medium-altitude long-endurance UAS.
The UK’s Royal Air Force (RAF) has approved BriteCloud, the expendable active decoy system developed by Leonardo for front-line use, and deployed it on the service’s Panavia Tornado fleet.

“The BriteCloud project—a drink-can-sized expendable decoy—is now ready for deployment on Tornado and easily adaptable for other platforms,” Air Chief Marshal Stephen Hillier, chief of the Air Staff, said during a speech in London in March. He went on to praise this RAF, Defense Science and Technology Laboratory and industry project as a “world-first of this new form of radar-defeating protective technology.”

The system’s rollout follows March 2017 flight trials during which RAF Tornados released several dozen BriteCloud units to develop a concept of operations, according to Leonardo.

There has been no specific confirmation, from either the Defense Ministry or industry, that BriteCloud is deployed on Tornados flying combat missions against Islamic State group militants over Syria and Iraq, nor whether it was onboard aircraft involved in the early April strikes on Syrian chemical weapons facilities. The Tornado is due to be retired from RAF service next year.

For program insiders at Leonardo’s plant here—where BriteCloud was designed and developed and where the decoy units are assembled and tested—the RAF’s announcement marks a major milestone.

“It does send a strong message that this is a mature product that is effective and ready for use,” says Jon McCullagh, Leonardo head of sales for combat air platforms and a former RAF Tornado qualified weapons instructor. The company cannot reveal the number of BriteCloud units ordered or the contract value, but McCullagh confirms deliveries and production are underway for a “multimillion-pound” order.

BriteCloud development was the first program contracted by the RAF’s Rapid Capability Office (RCO), established in 2017 to help streamline new-technology acquisition.

Fielding BriteCloud on the Tornado “underlines the success of the idea of the RCO,” McCullagh says. “We signed the contract last March, they looked at the trial data and brought it into service within 12 months. That’s good for the [Defense Ministry] and good for us.”

RCO allows the RAF and suppliers to focus on capabilities rather than delay initial deployments over issues such as long-term support. “[The RCO model] allows us to meet regularly and discuss progress and change the direction the program goes in or [its] goals,” McCullagh says. “[It gets] development of a new capability started and in place, so they can look at the other lines of development to support its throughlife.”

BriteCloud is available in two formats: The one supplied to the RAF for the Tornado is the same size and shape as a standard 55-mm flare and used
Until recently, Israeli companies were developing the most advanced electronic warfare (EW) systems for combat aircraft and helicopters. Now, as unmanned aircraft systems (UAS) take over more missions from the Israeli Air Force’s manned platforms, companies are turning their attention to the “little brothers” of these combat-proven systems.

In the past, the sense was that UAS did not need protection because they are not manned and are relatively cheap. “But that has changed dramatically,” says Eytan Eshel, vice president of Elbit Systems’ Elisra EW and signals-intelligence division. Not only are unmanned aircraft important to protect, but the cost of the systems and the payloads they carry has made them even more valuable.

They are also vulnerable, given threats of ground fire and cyberattacks. The first publicized cyberattack was on Dec. 4, 2011, when a U.S. Lockheed Martin RQ-170 Sentinel was captured by Iranian forces near Khashmar. The Iranian government announced it was brought down by its cyberwarfare unit, which took control of the aircraft and safely landed it.

Since then, electronic threats to UAS have grown. The air force’s flight-test center is working with other special units of the Israel Defense Forces to create new regulations to protect operational UAS from cyberattacks.

“At this stage, we are focusing our efforts on asking the right questions. We ask the manufacturers and the operators to understand the vulnerabilities and the possible actions that may minimize them,” an air force source says.

In addition to regulations, the Israeli Air Force is working with industry on technological protection. UAS flight-control systems must be guarded. In most cases this involves protection of the data link used by the ground station. Another effort is to protect the payloads, as systems to hack UAS have proliferated from Iran across terror organizations in the Middle East.

**Even platforms as small as IAI’s BirdEye 650D, with a wingspan of 4 m (13 ft.), are worth protecting from signals interference.**

Israeli defense industries are developing two types of EW payloads for UAS—one for self-protection and another that disrupts the enemy’s electronic systems, either for ground-to-air missile batteries or to limit fighter aircraft operations in a certain area.

Most, but not all, of the special EW systems for UAS developed by Israeli companies are classified.

One unclassified program is the Light Spear self-protection and jamming system for UAS developed by Elbit. It is a compact EW system based on multiple digital radio-frequency memory-jamming channels, working in parallel and covering a wide spectrum.

Elta, the electronics subsidiary of Israel Aerospace Industries (IAI), has developed a variety of EW payloads for fighter aircraft. In recent years, it has also developed EW payloads for UAS.

The trick is to not completely block the enemy’s transmissions, says Guy Alon, marketing director of Elta’s signals intelligence, EW and communications division. “The wiser thing is to
change is how do I, within the current [human-machine interface], realize or utilize all those extra options? Part of the answer is that we already have a very integrated DAS that gives me integrated maneuvers, chaff, whatever expendables are available, as well as on-and-off-board electronics."

Leonardo has received expressions of interest in BriteCloud from a number of other air forces, both for fighters and platforms based around business jets. McCullagh notes the latter have similar radar cross-sections to fighters, so the present BriteCloud iteration should suffice. Integration onto other flare-dispensing platforms, including helicopters and transport aircraft, is possible with further development.

“This product, as it is, is not really suited to large transport aircraft yet,” he says. “We would need a more powerful product to overcome the radar cross-section issue, and there are some technical challenges to that. But we have had a lot of interest from people who also have transport aircraft—so I’m sure there will be as much interest in another product as there is in this one.”

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Countering UAS Across Government

> DEPARTMENTS SEEK RELIEF FROM PROVISIONS OF U.S. CODE
> WHITE HOUSE PROPOSAL MODELED ON DEFENSE AUTHORIZATION

Bill Carey Washington

Gradually but surely, the legal authority to disrupt or take down small unmanned aircraft systems (UAS) is expanding across agencies of the U.S. government. With that authority, counter-UAS systems will be applied to enforce the boundaries of a national patchwork of sensitive sites and facilities.

The defense act President Donald Trump signed into law in December grants the Defense Department authority to track and use “reasonable force” to destroy drones intruding on military bases. The provision expands permission Congress granted in the previous-year’s defense authorization bill and complements airspace restrictions the FAA implemented above 183 military facilities in April 2017.

The FarAlert acoustic drone detection sensor could be one way to spot and counter rogue drones.

Notably, the latest defense legislation also restored a national registry of drone hobbyists the FAA rushed to establish in December 2015. A federal appellate court had ruled the registry was unlawful.

More recently, the Trump administration has floated draft legislation to provide the Department of Homeland Security (DHS) and Justice Department a “tailored grant of authority,” modeled on the grant of counter-UAS authority to the Defense Department to track, disrupt, disable, seize or destroy an errant drone. Protection would be afforded to select “covered facilities and assets” and run through 2023.

Among facilities or assets covered would be “moored or underway” vessels of the U.S. Coast Guard and Customs and Border Protection agency; protection operations of the Secret Service, FBI and U.S. Marshals Service; and penal, detection and correctional operations of the Federal Bureau of Prisons, according to a five-page draft.

Standing in the way are restrictions expressed in Titles 18 and 49 of the U.S. Code, said Brendan Groves, counsel to the deputy attorney general, during an April 19 panel discussion hosted by the Information Technology and Innovation Foundation in Washington.

“Why do we need legislation to enable these activities? Right now, the use of effective tools to defend against this new and growing threat is hamstrung by a variety of federal laws that were passed when the only time you saw a drone was when you watched ‘The Jetsons’ on TV,” said Groves. “These legal issues create great uncertainty with respect to the employment of these technologies and we think legislative relief is necessary to provide [counter-UAS] operators the certainty they deserve to execute their responsibilities.”

Title 18 is the main U.S. Code section on federal criminal laws; its Section 32 prohibits damaging or destroying an aircraft. Within the code, the Wiretap Act prohibits law enforcement agencies from intercepting “wire, oral or electronic” communications without a court order. The Pen Register Act prohibits use of pen registers—devices that record or decode outgoing electronic communications—as well as “trap-and-trace” devices that trace incoming communications. A section of Title 49,—relating to transportation—prohibits “seizing or exercising control of an aircraft.”

DHS and the Justice Department are not the only federal agencies with an interest in counter-UAS authority; the Interior Department needs it to prevent rogue drones from interrupting wildfire-suppression activities, Groves advised.

“There are other legitimate federal interests that are not accounted for under this proposal. The thought was to proceed in a phased approach, to prove to the Congress and the American public that this authority would be used in a rigorous and a responsible manner to protect core missions and assets, but in the hopes of eventually expanding from that premise to include additional activities that are important to protect,” he said.

The Justice Department also has heard from private companies, the petrochemical industry and owners of stadiums and amusement parks expressing “serious misgivings” about the drone threat.

Anh Duong, UAS program executive officer with the DHS Science and Technology directorate, says her department wants to see drones safely and securely integrated into the National Airspace System and with that as a goal “in essence, counter-UAS as an enabler of integration.” There are plenty of systems available, she notes.

“In terms of counter-UAS technologies, the market is full of solutions ... from radars to EO/IR [electro-optical/infrared], to acoustic to radio frequency,” says Duong. “A lot of those solutions were developed for military applications, so a lot of them have not been tested in homeland security settings, especially in urban settings. That’s a gap the [DHS] is trying to close quickly.”

In March, Rep. Vicky Hartzler (R-Mo.) introduced similar legislation to the Trump administration’s proposal—the Safeguarding America’s Skies Act (H.R. 5366)—that would amend Title 18, allowing the Homeland Security and Justice departments to track, redirect, confiscate or destroy rogue drones. The bill was referred to the House Judiciary, Transportation and Homeland Security committees.

Panelists expected the House Homeland Security Committee, whose chairman is Rep. Michael McCaul (R-Texas), would report out approved legislation. “We’ll pass on the opportunity to participate at this time,” the committee’s deputy director of communications responded, when asked about the next step. 📰
Military unmanned aircraft systems (UAS) tend to be either large, long-endurance platforms carrying advanced sensors too expensive to throw away, or small, shorter-range vehicles with simpler payloads cheap enough to be attributable, meaning somewhat disposable if not expendable.

DARPA is trying to change the paradigm and allow lower-cost UAS to carry more advanced payloads by enabling them to be air-launched and recovered in volleys by a host aircraft. This would both extend their range and allow military planners to take more operational risk as expensive payloads would be recoverable.

Dynetics has been selected to demonstrate its airborne launch and recovery system under a 21-month, $32.5 million contract for Phase 3 of DARPA’s Gremlins program. The company was chosen over the competing Phase 2 performer, General Atomics Aeronautical Systems.

For General Atomics, after its December 2017 failure to win a place on the U.S. Air Force Research Laboratory’s Gray Wolf swarming low-cost cruise missile program, losing Gremlins is a blow to its plans to develop a family of small UAS to complement its Predator family. The company declines to comment.

Gremlins is a major win for Dynetics, and Phase 3 is to culminate by late 2019 in flight demonstration of the recovery of four UAS within 90 min. to a Lockheed Martin C-130 host platform, says Tim Keeter, Dynetics deputy program manager and chief engineer for Gremlins.

The docking system is lowered on a pylon from the open cargo ramp of a C-130 flying at up to 150 kt. This deploys a capture device, akin to an aerial-refueling drogue, that stabilizes a safe distance below and behind the aircraft.

The UAS rendezvouses with the host aircraft and docks with the capture device using a precision navigation system. The UAS then powers down and is winched up to sway braces, secured, mechanically lifted into the cargo bay and stowed.

During Phase 2, Dynetics conducted ground and flight tests of the system, the latter using a C-130A operated by team member International Air Response. These demonstrated the ability to safely deploy, stabilize and retrieve the docking system, says Keeter.

The team also demonstrated safe separation of the UAS, but this did not involve a fully functional air vehicle, he says. Team member Kratos Unmanned Aerial Systems is developing the clean-sheet UAS, which is powered by a Williams International turbojet.

The purpose-designed UAS itself will undergo flight testing ahead of the Gremlins demonstration. For those flights it will be ground-recoverable, by parachute and airbag, so that vehicles can be recovered, refurbished and reused, Keeter says.

The Gremlins demo will use a roll-on docking system that requires no modification of the C-130, but the design is adaptable to other aircraft, he says. The capture device will be on the centerline and well below the aircraft, in clean air for stability during launch and recovery.

Gremlins is intended as an enabler for other DARPA programs that are developing technologies for swarms of cooperating unmanned aircraft. Keeter sees several benefits, including smaller airframes because the UAS do not need to carry extra fuel to launch from and return to an airbase.

UAS with limited design lives that are selectively recoverable—but inexpensive enough to be attributable—will also reduce cost per mission, he says. The ability to launch and recover volleys of UAS will allow multiple high-fidelity sensors to be distributed over a large area and their data fused together.

Gremlins does not include payload development. Keeter says Dynetics is working on the capability to support collaborative operations by multiple UAS equipped with advanced sensors. This includes managing multiple UAS simultaneously from the host aircraft.

“We have concepts for payloads that we are putting in front of stakeholders for experiments late in Phase 3 or in follow-on programs,” Keeter says. In an unusual move for DARPA, there is not yet a service to which Gremlins technology will be transitioned. “We are exploring opportunities with several transition partners and are not committed to a single organization,” says Scott Wierzbanowski, DARPA program manager.

“Interest is strong with both the roll-on/roll-off capability of the Gremlins system, as it does not require any permanent aircraft modification, and a wing-mounted system to provide greater flexibility to a wider range of aircraft,” he says. “We selected the C-130 as a demonstration platform but could easily modify the system for another transport aircraft or major weapons system.”
Almost a decade ago, a small Seattle-based company won a NASA space-elevator challenge by beaming laser power to a robot that climbed up a cable suspended from a hovering helicopter. That company, now called PowerLight Technologies, is on the verge of launching power beaming commercially: initially over fiber to tethered unmanned vehicles, but soon after wirelessly to free-flying unmanned aircraft.

Founded in 2006 as LaserMotive, the company in 2012 conducted a demonstration with Lockheed Martin in which power was beamed to a Stalker unmanned aircraft fitted with a laser receiver. The UAV flew for 48 hr. in a wind tunnel on laser power, and was then flown outdoors in day, night and rough-weather flight tests.

Now PowerLight is working under U.S. Defense Department contract to advance and transition the technology to provide wireless “free space” power beaming to unmanned air and ground vehicles and their payloads. This will extend endurance and, by sending data via the same laser beam, increase the bandwidth available for sensor information.

Power beaming converts electricity to laser light and beams it to a photovoltaic receiver that converts the photons back into electricity. “Through a number of small Defense Department and Navy contracts, we have been able to validate that the technology is real and safe and there is a viable way forward,” says CEO Richard Gustafson.

“We have over a decade of work behind us,” he says. “Timing has been everything, and now everything is moving in the right direction to bring the technology to market.”

The first step is to send optical power over fiber. This is inherently safe, as light cannot escape, and is lighter than sending electrical power over copper cable. PowerLight has demonstrated sending 70 watts of power over fiber to an unmanned aircraft to fly longer with heavier payloads.

Free-space power beaming via steerable laser will enable unmanned aircraft to fly longer with heavier payloads.
Jetex Flight Support Partners With Electric Aircraft Developer

Graham Warwick Washington

International fixed-base operator Jetex Flight Support believes electric aircraft will be viable alternatives to business jets for short-range private flights. The company has partnered with startup electric-aircraft developer Wright Electric and plans to deploy a charging infrastructure across its network of locations.

“We see a lot of potential for this,” says Sunny Landeros, brand and communications manager for Dubai-based Jetex, noting the time customers can save by flying even short distances between cities via private aviation rather than on airlines.

Los Angeles-San Francisco, London-Paris and Rome-Madrid are examples of markets where private aviation can provide “really great time savings,” says Landeros. “In the Middle East, Dubai-Bahrain is under an hour by air; and we have customers who fly weekly.”

Wright Electric founder and CEO Jeff Engler says the startup’s long-term strategy is still to develop an all-electric narrowbody airliner for short-haul markets such as London-Paris and New York-Boston. “But commercially available batteries are not sufficiently energy dense, and there is no certification basis. The best available is Part 23, and that limits us to under 12,500 lb. [takeoff weight].” Wright’s near-term goal “is to get something certified,” Engler says. The company is now focusing on developing a nine-seat hybrid-electric aircraft that can be certified under Part 23. The company is working on modifying an existing aircraft, which it hopes to fly by the end of 2018 or early in 2019.

Engler sees two markets for such an aircraft, one of which is business aviation. “It has lots of similar flight profiles: 30-40% of flights are under 350 nm.” The other is for specialist applications including skydiving and seaplanes, for which short range is not such a drawback.

Jetex sees advantages in electric aircraft for short-range private flights in terms of lower emissions and operating costs. “The cost of maintenance will go down over time versus conventional aircraft, which will increase the appeal of short-haul flying by making it more cost-effective,” says Landeros.

When it was approached by Engler, Landeros says Jetex saw the opportunity to build on electric-aircraft technology globally, instead of just in the U.S. or Middle East. “We can spin this out through our entire network,” she says, and support aircraft from other manufacturers and not just Wright.

Jetex has 30 locations worldwide and plans to grow to 50 by 2020. “We are expanding rapidly, especially in the Middle East, which is a growing market for private aviation,” she says. “We are opening in Oman, and Dubai-Oman is a perfect market [for short-haul electric aircraft].” Saudi Arabia is another one.

The company’s locations in Rome, Madrid and Barcelona, Spain, are other key sites for electrification. “We wanted to be the first company to commit to putting in the infrastructure to support electric aviation and do something for the environment,” says Landeros.

Converting an existing nine-seat aircraft to hybrid-electric propulsion will reduce fuel consumption and operating cost while increasing redundancy and safety, says Engler: “Having the turbine engine and electric motor will provide backup power in case of a failure.

The company has built a propulsion-system test stand with motors, batteries and cooling systems, and is about to take delivery of a turbine engine to integrate into the drivetrain for testing. Engler notes that BASF subsidiary Sion Power plans to have more energy-dense rechargeable lithium-metal batteries on the market by year-end.

Because of battery limitations and certification constraints, other startups developing electric aircraft also are targeting the short-haul market. Zunum Aero, backed by Boeing, is developing a 12-seat hybrid-electric regional aircraft while Israel’s Eviation Aircraft is working on an all-electric nine-seater. Israel Aerospace Industries has announced it also is developing a short-haul electric aircraft. ©
Chinese Bizjet Buyers Disregard Tariff Threat

Bradley Perrett Shanghai

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o far there is no panic. China’s proposed special tariffs on U.S. aircraft may look potentially damaging to Gulfstream, but the company reports prospective buyers are unfazed. Anyway, there are reasons to think new Chinese owners of Gulfstream aircraft could sidestep the import taxes if they are finally imposed.

Possible customers seem to assume that Washington and Beijing will find a way out of their trade dispute, says Gulfstream President Mark Burns. The U.S. on March 22 and China on April 4 announced plans for special import taxes on each other’s goods.

The proposed Chinese tariff could hardly have come at a worse time for Gulfstream, just 13 days before the opening of the annual business aviation show in Shanghai, when manufacturers have their best chance to exhibit aircraft to potential buyers. China’s proposed special tariff on U.S. aircraft would apply to those with empty weights of 15-45 metric tons (33,000-99,000 lb.).

But Burns says: “It does not appear to have lessened interest in our products at the show. . . . I don’t see it having stopped any discussions.”

“Most customers that we have spoken with feel like [the dispute] will be resolved,” Burns told reporters at the show, the Asian Business Aviation Conference and Exhibition. The U.S. and China have both left the door open to negotiations.

Although the company president does not mention this factor, customers are no doubt considering that, from their points of view, there is plenty of time for resolution: Gulfstream is unlikely to be able to deliver an aircraft to them in less than two years.

And when it does, the aircraft, though operated and maybe owned by mainland Chinese, need not be imported and therefore would not be subject to Beijing’s taxes. That is because buyers could easily enough use registrations from outside of mainland China and keep their aircraft based abroad, says Jeffrey Lowe, managing director of Hong Kong consultancy Asian Sky Group. There is already a tendency among Chinese buyers to keep aircraft elsewhere, because nonmainland registration and basing attract less attention.

Perhaps a few buyers who wanted a Gulfstream aircraft but insisted on mainland basing would turn to other makers, says Lowe. But the numbers could not be great.

Gulfstream delivered 20 aircraft to mainland China, Hong Kong, Macau and Taiwan in 2017. (All four economies are counted as a single market because of that mainland habit of placing aircraft in nearby territories.) The number last year delivered to the mainland alone is not known, but historically almost half have gone elsewhere. At the end of 2017, there were 113 Gulfstream aircraft based in mainland China. Another 86 were in Hong Kong, Macau and Taiwan. The handful of sales that could be diverted by the tariffs compares with Gulfstream’s global deliveries of 120 aircraft in 2017.

Burns evidently sees the threat as serious, even if there has been no immediate effect. Imposition of artificial barriers certainly would make it “difficult for us to compete,” he says.

The beneficiaries would be Bombardier and Dassault, which consistently trail Gulfstream in China. But Dassault, at least, seems unenthusiastic about the prospective tariffs helping it to gain sales at Gulfstream’s expense. “Competition should be fair,” Dassault’s senior vice president for civil aircraft, Carlos Brana, said at the show.

A surge in Chinese purchases of secondhand aircraft indicates a return of confidence among Chinese buyers that should translate into stronger sales of new aircraft. In its annual fleet survey, Asian Sky Group found that 39 preowned aircraft arrived in mainland China, Hong Kong, Macau and Taiwan last year, compared with only 19 in 2016. That is consistent with other signs that Chinese demand, which dried up after 2013, is recovering, says Lowe.

Gulfstream exhibited extensively at this year’s Asian Business Aviation Conference and Exhibition.

Renewed demand should show up first in arrivals of used aircraft, which are received very soon after a contract signature, rather than in deliveries from manufacturers. The same revival of confidence should be affecting demand for new aircraft, and indeed Burns says that his company is handling more inquiries than before.

An anti-corruption crackdown that began in 2013 dissuaded many wealthy people in mainland China who might have otherwise bought aircraft. They evidently decided that keeping a low profile was important. But a year ago Asian Sky picked up signals that “negative public image” had declined as a factor influencing decisions to buy. Also, Dassault says demand in China is stronger than at any time since 2013.

The fleet of business aircraft in mainland China and adjoining Chinese-speaking territories expanded 7.6% to 512 last year, compared with 4.4% growth in 2016. •
HondaJet Output Moving to Six Aircraft a Month

> MOST OF THE 83 AIRCRAFT IN SERVICE ARE IN THE U.S.

> BUT THE COMPANY HAS SECURED CHARTER CUSTOMERS IN FRANCE AND CHINA

Bradley Perrett  Shanghai

Honda Aircraft Co. production has overtaken that of its closest competitors in the light business-jet market, with steep rises in output still scheduled.

The company is building its HA-420 HondaJet light business aircraft at a rate of four a month and preparing to shift to five a month this year, says CEO Michimasa Fujino. Probably by the end of 2019 the company will be building six HondaJets a month, the designed capacity of the company’s Greensboro, North Carolina, plant, he says.

Still, these plans indicate a slower ramp-up than discussed in 2016, when a spokesperson said the company, owned by Honda Motor, would build 6-7 aircraft a month in 2018.

Honda Aircraft handed over 43 HondaJets in 2017, only the second full year of deliveries, according to the U.S. General Aviation Manufacturers Association. This was ahead of two very closely comparable aircraft: the Cessna Citation M2 and Embraer Phenom 100, for which 2017 deliveries were 39 and 18, respectively. The HondaJet and Phenom 100 have the same gross weight, 4.8 metric tons (10,600 lb.); the Citation M2 is only about 40 kg (90 lb.) heavier.

The first HondaJet was delivered on Dec. 31, 2015, after a protracted development program that ran at least five years late. The type is unusual among private aircraft in using a composite fuselage, to reduce weight and improve surface finish. And it is unusual among all jet aircraft in having wing engine mountings, chosen in part to reduce cabin noise and avoid the structural obstruction of the rear fuselage that would be necessary with tail mounting. The engine is the GE Honda Aero Engines HF120, generating 2,050 lb. of thrust.

Honda Aircraft is managing the rise in its production rate by exploiting the learning curve, the tendency for people to make things faster with practice. As the company’s output accelerates, employment will remain steady at the current level of 1,700-1,800, says Fujino, speaking to Aviation Week at the Asian Business Aviation Conference and Exhibition (ABACE) in Shanghai. Of that total, 600 people are employed on touch labor in manufacturing.

Of the 83 HondaJets delivered by mid-April, about 80% are flying in the U.S. But the U.S. share of the backlog is smaller, as the company widens its sales efforts, Fujino says. He declines to state the size of the backlog.

Planned use of HondaJets by a charter operator at Guangzhou, in southern China, is expected to generate more sales by introducing possible buyers to the type. Business aircraft sales to China are dominated by large types that can be afforded only by large companies or billionaires. But Honda Aircraft notes that there are many people in China who do not have that much money yet are still rich enough to buy its product. Private jets of this size cost about $5 million.

The HondaJet operator at Guangzhou will be newly established FlightJoy Aviation Co., which will also manage aircraft for owners. Honda Aircraft’s subsidiary at Guangzhou Baiyun International Airport is expanding by 8,800 m² (95,000 ft.²) to add a sales showroom and service center.

Meanwhile, ANA Holdings, owner of All Nippon Airways, plans to use HondaJets for charter and feeder flights to connect passengers to its network at major travel hubs in North America and Europe. ANA says it is setting up a new company, ANA Business Jet Co., in partnership with Japanese trading company Sojitz, to offer the charter flights; the service will begin in mid-2018.

At first, HondaJets will provide the connections to and from Los Angeles and Chicago, Fujino says; the next base will be Honolulu. Although a specialist general aviation subsidiary will operate the aircraft at first, Fujino suggests that All Nippon itself may eventually order HondaJets: “In the future, the business model may evolve to the next level,” he says.

French air taxi service Wijet became the first airline customer for the Honda Aircraft exhibited the HondaJet at the ABACE show in Shanghai in April.

HondaJet in February, when it signed a memorandum of understanding for 16 aircraft. Deliveries under the contract, valued at $78 million at catalog prices, were scheduled to take place over the 18 months beginning March 2018.

Wijet’s pricing gives a good idea of the salability of HondaJet services: the company’s planned charge for a 400-km (250-mi.) flight from Paris to Geneva with same-day return begins at $6,209, or $1,242 for each of five seats; for the 2,100 km between Paris and Marrakech, Morocco, near the limit of the HondaJet’s range, the price would be $17,680 with same-day return.

The importance of low fuel consumption to charter operators was one reason for Honda Aircraft’s decision to make the fuselage out of composite. It also considered that private owners who fly more than 300 hr. a year would similarly appreciate the fuel savings, says Fujino. A third group is private owners who personally fly the aircraft, rather than employ pilots, and like the higher flight performance afforded by low weight. ☺

—With Molly McMillin and John Morris
Boeing rolled out the first of three 737-9s for United Airlines. The airline plans to put the aircraft into service by midyear. This is a year of transition for almost all involved players. It is the last year in which the classic Airbus A320 family and the Boeing 737NG will be produced in large quantities. Starting next year, the A320neo and the 737 MAX will dominate. This year, not only is the first serious production ramp-up of the Bombardier C Series to occur but so is its imminent integration into the Airbus product portfolio—with regulatory approval expected by mid-year. At the same time, Embraer has delivered the first E190-E2, an aircraft it hopes will become a significant player at the lower end of the narrowbody market along with its larger variant E195-E2, which is scheduled to enter service next year.

New competitors also are being prepared for commercial service, with the United Aircraft Corp. (UAC) MC-21 and Comac C919 in flight tests. Their market penetration likely will be limited mostly to their home countries, but in the case of the Chinese C919, that is a nice problem to have. However, these events are not taking place in a vacuum. “The last eight years have witnessed an unprecedented (except for the 1960s, the first years of the jet airplane) run of world traffic growth of 7% almost every year,” Edward Greenslet writes in “The Airline Monitor,” a regular in-depth analysis and forecast of industry trends: “Not only are producers seeing strong demand for their products, the airlines behave as if the recent traffic numbers are the new normal.” Greenslet adds that “both sides of the demand equation are, in effect, proceeding on the assumption that recent conditions will continue indefinitely.” That is a mistake, he believes, because “the prospect of seeing a time of lower demand is as near to a certainty as anything can be. The only question is when.”

But for now, no one seems bothered. In fact, because of the current demand growth for air travel, “deliveries for this and next year are actually below what the industry needs, lending support to the rate increases that are planned,” Greenslet states.

And so at this stage, production...
AWAY

“we have to deliver a complete aircraft, and suppliers have to be able to support the increase,” he adds.

Which describes exactly Airbus’ problem. In the first three months of 2018, the OEM delivered only 95 single-aisle aircraft, just over 30 per month and well short of its own targets. “We have dozens of gliders parked in Toulouse and Hamburg,” Enders says, referring to A320neos and A321neos awaiting Pratt & Whitney PW1100G engines.

Airbus was forced to suspend deliveries of Pratt-powered aircraft in early February after a recently introduced modification to the engine led to several in-flight shutdowns and aborted takeoffs. Deliveries have yet to be resumed; Enders also has publicly highlighted delays in engine deliveries by CFM International, which provides the alternative powerplant, a clear sign of Airbus’ sense of urgency around the issue. Enders clearly expects 2018 deliveries to be even more “backloaded” than last year. The company delivered 718 aircraft in 2017, more than 100 of which were handed over in December. The OEM wants to deliver about 800 aircraft in 2018, most of them single-aisle jets and a growing portion of them Neos.

A320neo-family deliveries are still dominated by the A320neo, although the A321neo’s share is rising. Greenslet believes the A321neo “certainly appears to have come closer than any other model to defining the sweet spot for single-aisle aircraft over the next two decades.” The A319neo is currently still in flight tests and is planned to be delivered to its first operator in 2019. Much more important, next year also marks the entry into service of the A321LR, which is capable of long-haul missions across the Atlantic, from Europe to Asia or North America to Brazil.

At the same time, Airbus is pushing out a decision on whether to go ahead with upgrades of its A320neo-family aircraft. Schulz says that “we cannot fix everything at the same time,” referring to in-service issues, the output increases and potential product development. While “we don't cancel anything,” Airbus’ management has come to the conclusion that “we need to deliver what we committed to first.”

Airbus has been studying both minor and more substantial upgrades to the A320neo and A321neo, dubbed A320neo plus and A321neo plus-plus. Both studies entail stretching the aircraft, while the plus-plus variant would include more difficult changes such as a new composite wing. Industry reaction to the plans has been mixed.

The project was at least partially designed as a response to Boeing’s proposed new midmarket airplane (NMA), which has yet to be launched. Airbus management's thinking centers on being able to provide an upgraded version of the A321neo well ahead of the expected NMA entry into service. While there have been expectations of an NMA launch decision this year with the aircraft entering service around 2025, Boeing is still working out the business plan—and aircraft pricing in particular—and there has been speculation the aircraft may come later than anticipated. If that happens, Airbus would gain time to fix problems with the current model, ahead of jumping to a new version, as well as allow it to further consider its product strategy. If Boeing moves ahead sooner, Airbus may risk coming under more pressure for a strong response.

Boeing, meanwhile, continues a fine balancing act at its facility in Renton, Washington. It is simultaneously pumping out 737s at unprecedented...
rates, introducing a new model into the production system and readying for development of the stretched -10 next year.

As it moves into the next critical phase of its MAX introduction strategy, Boeing knows it cannot afford any slips, with the 737 increasingly vital to its cash flow. Of the 184 Boeing commercial aircraft delivered in the first quarter of 2018, some 192 were 737s, including the 10,000th member of Boeing’s smallest jetliner family—a 737-8 MAX for the new variant’s launch customer, Southwest Airlines.

Since the first 737-8 was handed over in May 2017, deliveries of the MAX have begun to accelerate on plan, with 74 in the hands of operators by the end of December and another 40 by late April 2018. The tally includes the first 737-9, which was delivered to Lion Air in March 2018. The Indonesia-based low-cost carrier also made headlines in early April when it was confirmed as a previously unidentified customer for 50 737-10s.

Boeing, which is completing detailed design of the higher-capacity derivative this year, plans to begin flight tests of the final stretch model in 2019 and initiate deliveries in 2020. About 416 737-10s have been ordered by 18 operators since its launch at the 2017 Paris Air Show. Although this appears to be a relatively small portion of the 4,474 firm orders for the entire 737 MAX family announced through the end of March, Boeing says more than 1,500 positions are currently undecided or unknown.

As the higher-capacity model is Boeing’s principal counter to the highly popular A321neo, the company is also eager to bolster marketing and sales efforts for it, looking to sustain the MAX production line through the late 2020s. This year could be a vital one for sealing several campaigns with airlines that have been maintaining a watchful eye on the new stretch variant. According to Boeing, these potential customers have signed off on the finalized design of the novel landing-gear configuration that enables a 66-in. stretch over the 737-9, for an overall length of 143 ft.

The -10 extension consists of a 40-in. plug in the forward fuselage and 26 in. aft. The completely revised taller main landing-gear design, which combines a telescoping feature to shorten the leg and a semilevered lower element to move the aircraft takeoff rotation point aft, still fits within the existing wheel well but can extend to raise the body a further 9 in.

Although Boeing is reluctant to provide details of its backlog breakdown, there is no disguising the 737-8’s popularity. With an orderbook estimated at almost 2,330, the 737-8 accounts for the overwhelming majority of declared MAX orders. However, as narrowbody operators continue to upgauge and trend toward larger-capacity models as traffic and range capability grow, questions remain about the future 737-9 orderbook and to what extent it will be cannibalized by the newly available 737-10.

Announced orders for the 737-9 amount to a relatively modest backlog of about 116, but the true tally is thought to be more than 400. However, some erosion has inevitably taken place since the -10 became available, notably from United Airlines. In 2012, it became one of the main customers for what was then the largest variant, along with Lion Air, when it ordered 100 MAX 9s. United was among several operators that converted -9 orders to -10 in mid-2017, when the new model was firmly launched.

The U.S. carrier, which is expected to take its first three 737-9s by the end of April, converted 39 MAX 9 orders to -10, but with 61 firm positions, it still remains the single largest acknowledged customer for the 737-9. United is expected to receive up to 10 aircraft in 2018 and will put the first of the 179-seaters into service around midyear on routes from Houston and Los Angeles to Anchorage, Alaska; Austin, Texas; Fort Lauderdale, Florida; Honolulu; Sacramento, California; and San Diego.

While boosting the orderbook for the upper end of the MAX family against
the A321neo is urgent business for Boeing, the situation is arguably more critical at the lower end, where flight tests of the 737-7, the smallest member of the series, began on March 16. Despite a redesign of the -7 in 2016 at the request of launch customer Southwest Airlines and WestJet of Canada that added range and an extra 12 passenger seats to provide capacity for 138 in a typical two-class layout, the market reaction remains lukewarm.

Boeing is scheduled to spend the bulk of this year on the flight-test and certification program before delivering the initial 737-7 in 2019. The OEM also is banking on positive performance results from the test campaign to stimulate orders, which officially stand at fewer than 60. Boeing believes the aircraft’s range capability of 3,850 nm, the longest of any MAX version, could make it an attractive niche player for airlines looking to open new point-to-point routes in much the same way as the 787 has been.

Key to this capability are the aerodynamics of the MAX wing and redesigned tail cone, plus the propulsion improvements provided by the CFM Leap 1B. Together, these allow the MAX 7 to fly 1,000 nm farther and carry more passengers than its predecessor, the 737-700, and with 18% lower fuel cost per seat. Boeing thinks this gives the MAX 7 the advantage over its nearest rival, the Airbus A319neo. The aircraft, it says, carries 12 more passengers 400 nm farther than the smaller Airbus, with “7% lower operating costs per seat.” Other close rivals in the tightly contested 130-seat sector include Bombardier’s stretched CS300 and Embraer’s 195-E2.

Flight tests of the initial 737-7 appear to be on track, with the aircraft focused on certification high-speed air testing. A second aircraft is expected to join the flight-test program shortly.

After its market introduction in 2016, the Bombardier C Series is now about to enter a transformative phase, with Airbus nearing regulatory approval to take majority control of the program. There are differing views on how that will change the aircraft’s prospects and whether Airbus marketing efforts will be enough to turn around its fortunes. One school of thought is that nothing much will change, because Airbus sales representatives will prefer to sell the larger narrowbodies.

A different take is that Airbus will push the C Series hard because, absent a merger agreement with Embraer, Boeing has little to counter with. What is clear, however, is Airbus’ drive to reduce C Series production and supplier cost, the effects of which the OEM’s suppliers will likely see soon after the transaction has been approved.

Also new to the scene is the Embraer E2, with its predecessor still largely limited to regional operators. Embraer’s business case for the E2 rests on the assumption of much higher production volumes, so the aircraft needs to succeed in new market segments. JetBlue Airways is close to a decision on how to replace its current E1 fleet. If it opts to stay with the Brazilian manufacturer, the program and December 2017, respectively. The third aircraft is expected to make its first flight “before the end of the year,” Wu says. “In 2019, it is planned to have three more aircraft in flight testing, for a total of six.” That will complete the flight-testing fleet, according to current plans.

The second C919 has been under modification at Shanghai, where Comac is based, and is due to move to Comac’s flight-testing base at Dongying in April. These two aircraft will be used for hot- and cold-soak testing, too, Wu says.

At least nominally, the program would be protected by tariffs that China, responding to Washington’s taxes on Chinese goods, said on April 4 it would apply on U.S. goods.

### Narrowbody Deliveries by Model

<table>
<thead>
<tr>
<th>Model</th>
<th>Boeing 737NG</th>
<th>Boeing 737 MAX</th>
<th>Bombardier C Series</th>
<th>Comac C919</th>
<th>Irkut MC-21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliveries</td>
<td>2010</td>
<td>2011</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>ASK Growth</td>
<td>68</td>
<td>72</td>
<td>76</td>
<td>80</td>
<td>84%</td>
</tr>
</tbody>
</table>

Source: Teal Group

These included aircraft with empty weights of 15-45 metric tons (33,000-99,000 lb.). The upper end of that range was evidently defined by the C919’s specifications.

In practice, the tariff’s influence on the C919 program is unlikely to be great, if it is even imposed, because the consistently Chinese nationality of the program’s customers indicates politics, not competitiveness, is the chief influence on orders.

The last reported test flight of the Irkut MC-21, Russia’s new narrowbody aircraft, was in early November. Since then, neither Irkut Corp. nor UAC has revealed anything about the testing, although Irkut says certification trials of the MC-21-300 narrow-
body airliner continue, without providing further details.

The testing is now limited to one prototype. It was rolled out in June 2016 and took off for the first time in May 2017. After completing 20 flights under the factory test program in Irkutsk, the aircraft flew for certification trials to the Gromov LII Flight Research Institute in Zhukovsky, near Moscow, in October.

The second MC-21 prototype was rolled out at the Irkut facility in Irkutsk on March 25. The manufacturer reported that the second prototype had been assembled taking into account the results of the trials of the first aircraft.

Irkut did not say when the second prototype will fly, but Russian media cited an Irkut representative saying this could happen in May. The second prototype is expected to speed up the trials. “The introduction of new aircraft to flight tests will enable us to solve the key tasks of the program: to complete the certification of MC-21 in a timely manner, to launch mass production and to deliver the first airliners to the customer,” says Denis Manturov the Russian minister of industry and trade.

The third prototype was spotted in the final stages of assembly. Irkut says it has begun building the fourth test aircraft.

The company plans to receive Russian type certification for the MC-21 in mid-2019, to be followed by European Aviation Safety Agency validation a year later. The MC-21-300-baseline version will carry between 163 and 211 passengers over a distance of 6,000 km (3,700 mi.). It will be powered initially by a pair of PW1400G-JM engines.

The fourth prototype is expected to be equipped with Russian PD-14 engines in the second quarter of 2019. This engine is expected to get Russian certification later this year. The certification of the PD-14-powered MC-21 variant is planned for 2021.

The MC-21 backlog stands at 175 firm orders, mostly from Russian leasing companies. The country’s largest carrier, Aeroflot, is expected to be the major operator of this type. It firm ed its order for 50 aircraft through Avia Capital Services, a leasing arm of Rostec Corp., in February and is set to take the first delivery in early 2020.

Bombardier Overcomes Delays and Accelerates C Series Production

Graham Warwick Montreal

Production of Bombardier’s C Series airliner is finally picking up pace, as the manufacturer overcomes interior-completion delays that followed earlier issues with the availability of Pratt & Whitney PW1500G geared turbofan engines and problems with some suppliers.

The company has delivered just 30 aircraft since the first CS100 was handed over to launch customer Swiss International Air Lines (Swiss) in June 2016, many fewer than originally planned. But Aviation Week saw another four aircraft for Swiss and one for Air Baltic being prepared for delivery during an April 17 visit to the final assembly plant at Mirabel, near Montreal. All are to be delivered by June.

Those were among about 20 C Series aircraft seen in various stages of final assembly and completion at Mirabel, including the first CS100 for Delta Air Lines, Bombardier’s first U.S. customer. This aircraft, the first of 75 Delta has on firm order, is scheduled to be delivered in the fourth quarter.

Most of those 20 aircraft are longer CS300s, as work on the shorter CS100 was slowed after Boeing in April 2017 filed an anti-dumping petition against Bombardier over the pricing of Delta’s crucial April 2016 order.

With the rejection of Boeing’s petition by the U.S. International Trade Commission in January, and the end to the threat of import tariffs totaling almost 300%, CS100 assembly was restarted, says Rob Dewar, vice president of the C Series program.

The first Delta airframe is assembled and systems are being installed. It is the first from any manufacturer to have K, band satellite Wi-Fi fitted on the assembly line, says Dewar. This avoids having to open up the aircraft later to install the dual-antenna Gogo 2Ku system.

The delayed ramp-up means most of the C Series orderbook still lies ahead, although new sales have remained slow. After strengthening the backlog in 2016 with orders from Air Canada and Delta, Bombardier lost momentum in 2017 when Boeing filed its petition, says Bombardier CEO Alain Bellemare.

With the October 2017 announcement of the agreement for Airbus to take control of the C Series program, Bellemare said: “We have regained momentum, and the level of activity is now the highest ever.”

The deal, which calls for Airbus to take a majority stake in the program, is expected to close by midyear, earlier than anticipated. “We are doing very well on integration and progressing well on closing,” says Bellemare. “The level of confidence is very high, but orders are paced by the customers.”

Although the threat of tariffs has lifted, Airbus and Bombardier are continuing with plans to set up a second C Series final assembly line for U.S. customers alongside the Airbus A320 line in Mobile, Alabama. The Mobile facility will comprise a single line, an exact replica of one-half of the Mirabel facility, Dewar says. Sub-assemblies and systems for the U.S. line will come directly from the same sources feeding the Mirabel line.
Hainan Airlines will take on a greater role as HNA’s Chinese mainland long-haul specialist while also building up at Shenzhen to create a second main base for intercontinental services. In contrast with the group’s fragmented intercontinental activity among various subsidiaries over the past few years, future long-haul routes will routinely be opened by Hainan Airlines, industry sources say.

Accordingly, Airbus A350s ordered or leased for HNA subsidiaries Capital Airlines and Tianjin Airlines instead will go to Hainan Airlines, the group’s original and largest carrier. The transfer of Boeing 787-8s to HNA’s Suparna Airlines from Hainan Airlines will be reversed. And HNA has signed a preliminary agreement to buy 15 A350s that presumably will be assigned to Hainan Airlines, the industry sources say.

An earlier policy of concentrating Airbus A330s with HNA carriers other than Hainan Airlines will continue, say the sources, who are all closely familiar with the group’s activities.

The new policies notably will enhance the status of Hainan Airlines and follow a capital reorganization in which the carrier this year took over HNA’s shareholdings in almost all of the group’s other carriers in mainland China, but not those based elsewhere.

The shape of Hainan Airlines’ network is changing, too. The carrier has stepped up development of intercontinental business at Shenzhen, making the rich southern Chinese city its second long-haul base, after Beijing, the sources say. The move should be seen as increasing competitive pressure on China Southern Airlines, the dominant operator at Guangzhou, 100 km (60 mi.) away, and on Cathay Pacific Airways, which is based next to Shenzhen at Hong Kong International Airport. The preliminary agreement to buy A350s was signed early in April; the timing of the order that is intended to follow is unknown. Suffering widely reported financial difficulties, the group may be unable to pay deposits immediately.

Subsidiaries previously have planned to operate A350s; some have appeared at Airbus’ Toulouse plant painted with the colors of Tianjin Airlines and Capital Airlines. Lucky Airlines has said A350s would replace its A330s.

By limiting the long-haul growth of its smaller carriers, the group will keep its widebody fleets at an economically small scale for longer (see table). On the other hand, the new policy will at least help avoid fragmentation of these little fleets.

Suparna has one 787-8 and was supposed to receive the other nine that Hainan Airlines retains. Under the new plan, Hainan Airlines will keep all 10, flying them alongside 36 787-9s that it has ordered. Suparna is a former freight carrier that HNA converted to passenger operations in 2015 with the ambition of using it to expand the group’s business at Shanghai. That included opening long-haul routes.

But Suparna’s planned role has been downgraded, reports one of the sources, suggesting the airline’s passenger services will develop more slowly than previously planned. Suparna did not move under the control of Hainan Airlines in the capital reorganization. Instead it is in HNA’s logistics division.

In another part of the HNA fleet reorganization, GX Airlines will transfer its 17 Embraer E190s to siblings including Fuzhou Airlines, afterward operating only Airbus A320-family aircraft. The seat-kilometer costs of the E190s are too high for GX, says one of the sources, adding that other airlines in the group are not keen on taking the aircraft. In general, they would prefer to operate nothing smaller than six-abreast narrowbody aircraft. Fuzhou currently has only Boeing 737-800s.

In Shenzhen, the municipal government is encouraging Hainan Airlines’ buildup and will support the move financially. The airline says it will open its sixth long-haul service from Shenzhen in October, connecting it with Vienna.

The opportunity to create a substantial long-haul operation at Shenzhen has arisen in part because, other industry sources say, Air China has limited the intercontinental expansion of Shenzhen Airlines, a domestically focused carrier which it partly owns and is based there. This restriction has frustrated the ambitions of municipal authorities, who believe intercontinental connections help drive economic growth.

Shenzhen, established in only the 1980s, is more prosperous than, and almost as populous as, Guangzhou, the provincial capital of Guangdong. But Shenzhen Baoan International Airport has had few long-haul air connections because Guangzhou Baiyun International, an official intercontinental gateway, is so close, and Hong Kong International Airport is even closer—40 km (25 mi.) away.

Shenzhen began to get intercontinental services in 2016, with municipal subsidies, but Hainan Airlines is moving ahead of competitors in building up a long-haul base there. In doing this, Hainan Airlines is going well beyond the scale of Shenzhen operations envisaged last year, when it agreed with the city government to add an average of one intercontinental and two Asian flights a year until 2020. At the end of the period, it would have 30 aircraft based overnight at Shenzhen, according to the agreement; “almost 15” would be widebodies.

—Research by Ryan Wang
CFM56 Probe Targets Blade Fatigue Cracks and Damage Pattern

> INSPECTIONS REVEAL NO WIDESPREAD ISSUES

> SOUTHWEST INSPECTING ALL ITS CFM56-7Bs BY MID-MAY

Sean Broderick Washington

Inspections on CFM International CFM56-7B engines since an April 17 accident tied to a fractured fan blade have not revealed a fleet-wide safety issue, and investigators have determined that the engine failure caused a large piece of fan cowl to strike the fuselage and break a window.

NTSB investigators revealed in a May 3 investigative update that the engine failure was contained, with two pieces of the fractured fan blade, in position No. 13, found between the other 23 blades and the outlet guide vanes. It also matched up a recovered piece of fan cowl and latching mechanism with witness marks on the fuselage beneath the broken window.

The NTSB revealed earlier that recovered parts of the blade exhibited cracking. Why the blade cracked, how a contained engine failure could cause the damage exhibited on the Southwest Airlines Boeing 737-700, and how the accident relates to a similar one involving another Southwest 737-700 in August 2016 are likely to be central to the NTSB’s continuing investigation.

Both accidents resulted from single fan-blade failures in No. 1 engines. Part of each blade remained attached to the fan hub, and fatigue cracks were found within each blade’s root. Debris caused significant wing and fuselage damage, and each cabin lost pressure.

In the 2016 accident, the aircraft suffered a 5 X 16-in. hole in the fuselage above the wing, though the passenger cabin was not penetrated. One passenger aboard the April accident flight was killed, and the broken window is believed to have been a key factor.

The FAA and the European Aviation Safety Agency (EASA) moved quickly after the April accident, which led to an emergency landing in Philadelphia, to mandate CFM-recommended inspections on high-use CFM56-7B fan blades. CFM’s original recommendations came in a March 2017 service bulletin based on the August 2016 accident, which resulted in an emergency landing in Pensacola, Florida. EASA mandated those checks in March, while the FAA was still finalizing its requirements.

CFM issued new recommendations, and EASA’s April 20 emergency airworthiness directive (AD) superseded the agency’s March order. While the NTSB has not publicly linked the accidents, the moves clearly signal that regulators and CFM consider the underlying issues to be the same.

The FAA joined EASA by also issuing an emergency AD on April 20. Regulators ordered ultrasonic inspections of blades on 680 engines with at least 30,000 cycles by May 10. EASA, following CFM’s lead, also required inspections of the remaining 13,300 CFM56-7B engines, all of which power 737NGs, at specific intervals. The

Similar, damage patterns in the CFM56 accidents have raised concerns.

FAA on May 2 issued a directive that mirrored EASAs requirements.

After about 60% of the initial inspections, “no imminent safety concern with the fleet has been uncovered,” says CFM, a GE Aviation/Safran joint venture.

The fan blades on the engine that failed in April had accumulated “more than 32,000 cycles,” the NTSB said in its latest update. They were last overhauled in 2012—10,700 cycles before the accident. The overhaul process included fluorescent penetrant inspections. The blades were lubricated and visually inspected six times between the overhaul and the accident as part of routine maintenance.

“The NTSB materials group is working to estimate the number of cycles associated with fatigue crack initiation and propagation in the No. 13 fan blade and to evaluate the effectiveness of inspection methods used to detect these cracks,” the board said. Following the 2016 accident, a CFM service bulletin added eddy-current inspections into the overhaul process, NTSB added.

Southwest decided after the April 17 accident to fast-track inspections on its entire CFM56-7B fleet—more than 1,400 engines—and finish them by mid-May. As of late April, it had inspected 25,000 of 35,000 blades and reported one anomaly—a cracked blade discovered in 2017.

While attention has focused on the cracked fan blades, the extent of the damage has generated equal concern.

“The loss of the single blade inside [the engine] should not have caused such a dramatic impact,” Southwest Chief Operating Officer Michael Van de Ven said.

Meanwhile, the NTSB has not provided an update on the August 2016 accident since September 2016. The NTSB said the probe “is an ongoing investigation” and a final report is expected “soon.”
A confluence of technological advances has made this improved and distributed flight management capability possible, says Carl Esposito, Honeywell Aerospace president of electronic systems. Honeywell already has developed highly integrated avionics systems with the Primus Epic for business aviation and Boeing 777 Airplane Information Management System, both dating to the mid-1990s, he notes.

Computer-processing and data-storage capabilities have advanced by orders of magnitude since then. Multicore technology, which leverages a single chip to run multiple applications concurrently, has produced higher-performing processors that consume less power; allowing an avionics manufacturer like Honeywell to embed more functions in software. The level of computing, coupled with software virtualization—emulating hardware functions through software—is driving step changes in software applications and the size, weight and power requirements of hardware, Esposito says.

Software “portability,” or usability, in different computing environments is helping Honeywell develop a distributed flight management system (FMS) capability in which an FMS can run on different architectures—whether on the ground or divided between the ground and aircraft. A future FMS could draw flight-relevant data from the internet “cloud” or remote servers through a data-link connection. This FMS “offboard” capability will benefit from better data analytics from the ground while relieving the processing burden of onboard systems.

“The flight management system, the way we’ve architected it, kind of doesn’t care if you have a MCDU [multifunction control display unit] hard keyboard or a touchscreen or a voice interface or a remote interface,” says Esposito. “The core flight management system functionality and capability around managing the aircraft, flying the flight routes is kind of abstracted from that user interface. We can evolve the user interface over time to match the category and classes of pilots that are using it through software interfaces.”

Broadband inflight connectivity to the flight deck and cabin opens opportunities to communicate data to onboard displays and systems as well as to send data off-board the aircraft. Crowd-sourced, aggregated weather information collected from the weather radars on multiple aircraft—one of Honeywell’s portfolio of “connected” services—provides a full view of weather along an aircraft's projected route. “With some of our low-cost connectivity solutions and an iPad, suddenly you...
can get global weather radar data. It’s really going to be a transformational thing,” says Esposito.

Providing weather information to the flight deck is one example. Another is sending health and performance data from auxiliary power units, environmental control systems and other components in real time to airline centers to inform maintenance predictive analytics. “You’re going to see a lot more capability of how we operate, manage and fly airplanes, aggregated on the ground, in many cases,” he notes.

Another advance Honeywell emphasizes is the evolution from knobs and dials to touchscreen displays, which the company has introduced on the Primus Epic-based Symmetry flight deck of the new Gulfstream G500/G600 business jets. Honeywell also is developing speech, gesture and other “modalities,” or interfaces for pilot controls.

Designing the various advances into highly automated, simpler-to-use, more compact flight decks will benefit from the emergence of the urban-air-mobility and hybrid-electric transport markets, says Honeywell, which counts itself among the traditional aerospace manufacturers eyeing those opportunities.

“We kind of live in the old world of separate products, even though we’ve integrated them on the same cards,” says Mike Stewart, Honeywell vice president of advanced technology. “We talk about a flight management system, displays, EGPWS [enhanced ground proximity warning systems]—that’s all going to kind of blur because they’re going to start trying to push all that down into smaller and smaller hardware platforms, which is going to make us integrate even more than we’ve integrated.”

Gregory Bowles, vice president of global innovation and policy with the General Aviation Manufacturers Association (GAMA), describes a new generation of systems design based on highly integrated, cross-checking systems, “simplified vehicle operations” and a pilot’s ability to fly flightpath vectors instead of directly manipulating controls.

Cirrus Aircraft began general aviation’s (GA) evolution from analog instruments to glass cockpits in 2003 with the single-engine SR20 and SR22, which initially were fitted with the Avidyne Entegra integrated avionics system and then Cirrus Perspective by Garmin. The next step after the integrated cockpit is expected to be the simplified cockpit, which will make flying easier and accessible to more people. Eventually, the left seat of some aircraft may become simply the “front seat,” or just another seat with the best view from the airplane, says Bowles.

“When you fly glass cockpits, the workload is easier, you’re monitoring more, you’re not doing the old mental calculations we do with round dials. But we never really took credit for that simplification,” he says. “We have the same currency requirements and there’s no simplification of being a pilot based on that. But the technologies we’re seeing right now, that people are starting to develop and field, have a potential to really make it easier to be a pilot and get credit for that,” Bowles notes.

Present-day autopilot and fly-by-wire (FBW) systems return control to pilots to hand-fly an aircraft and move its surfaces in the case of a system failure. With the new generation of systems design, reliability and robustness are expected to be enhanced through systems cross-checking, so when failures happen, the capability does not shut down. Bowles uses the example of a beyond-threshold difference, or “miscompare,” of sensor indications by attitude-heading reference systems.

“It’s a deeper level of integration, it’s thinking about second-order effects a little more deeply, adding reliability and redundancy,” says Bowles. “Today, we still have a lot of federated systems, and when systems fail we go back to the federated view. The idea here would be that you have multiple layers of integration so when one integrated layer has an issue such as a miscompare or whatever may be happening, there are other integrated layers that [provide] backup. The pilot is able to continue flying with the safety enhancing equipment; it’s not going offline.”

With an FBW system to keep an aircraft within its flight envelope, integrated with “refuse-to-crash” technology to protect against controlled-flight-into-terrain (CFIT) accidents, the pilot would not so much be in the loop, but “on the loop, directing the aircraft versus truly navigating, aviating and communicating,” says Bowles. Rather than manipulating flight controls, pilots would specify a vector for the airplane to fly.

“The iteration we’re seeing in front of us is that on these new generation of aircraft, you wouldn’t necessarily directly control flight controls, you would directly control flightpaths and the systems would decide what is the most optimal way for this aircraft to manipulate its flight controls on its own to give you the results you’re asking for,” says Bowles. “For example, you could move your flightpath vector onto the threshold of a runway, and the aircraft would continue to head to that point.”

The FAA says it is conducting multiple research activities aimed at reducing pilot workload and enhancing safety in general aviation aircraft; its goal is “to generate policy, guidance and standards for technology adoption in GA.” An FAA research and policy integration team is addressing challenges of certifying vehicles “where flightpaths are specified, instead of manipulating
a stick, rudder or throttle.” The FAA is testing an “EZ-FLY” flight-control scheme designed for non-pilots to manage flightpaths, using a variable stability FBW Ryan Navion single piston-engine aircraft. It also uses an FBW Diamond DA42 piston twin.

FAA-sponsored research projects range from developing optional safety enhancements “such as simple, affordable autopilots,” to envelope protection and alerting systems, and involve NASA, academia and industry partners. The agency says it is engaged with industry-standards development efforts, including ASTM International’s autonomy task group and indirect flight controls committee, which are developing standards for unmanned and FBW systems, respectively.

One system with potential for certification would protect against crashes, but represents “much more than a terrain awareness and warning system (TAWS),” the FAA says. It would draw information from a higher-resolution database than required by current technical standard orders for TAWS design and performance, taking into account an aircraft’s “specific energy/maneuver potential.” While the system could be coupled with flight controls to provide an automatic response, the pilot would always be in control and could override the system.

Certifying elements of a crash-avoidance system in small aircraft could help prevent accidents involving loss of control and CFTI, the top-two root causes of fatal GA accidents, the FAA says. Research into single-pilot operations (SPO) is ongoing, including by Airbus and Boeing as well as MRO organization ST Engineering. At the Singapore Airshow in February, ST said it was looking into expanding its cargo-conversion offerings to include unmanned freighters, a process that will begin by incorporating a single-pilot flight deck.

“By this reduction, the obvious benefit is a reduction in air crew cost by up to 50%. While an additional ground (remote) pilot is required, he can potentially enable RCO or SPO.

Consisting of hardware and software, IAS would serve as the second pilot in an RCO/SPO flight; they would use machine-learning concepts to perform functions without explicitly being programmed. They would have the ability to modify their behavior in response to the external environment and conditions.

Citing other research NASA has conducted into paradigms involving a “super dispatcher” or “harbor pilot” providing assistance to a pilot from the ground, the study assumed “part-time or scheduled, periodic support” from a ground operator is necessary for SPO. Critical issues would be design of the ground station, the security and content of the data link to the flight deck, and the expertise of the ground operator: “More research and development will be required, in addition to significant regulatory and societal change, for RCO or SPO to ever become a reality,” the researchers advise.

The findings of the high-fidelity experiment support the “criticality of the human’s role” and the adaptability of pilots in overcoming non-normal conditions, even in the case of SPO, the authors say. “The data also indicate, however, that single-pilot operations are not nominally acceptable due to the significant task demands and workload,” they add. “The pilots could overcome the circumstances presented, but rated the workload, safety and acceptability as being unacceptable in an emergency situation. There were notable flight-performance decrements during SPO compared to two-crew operations that suggest unacceptable, reduced safety margins.”

A provision in draft FAA reauthorization legislation that would establish a joint FAA/NASA research program for “single-piloted cargo aircraft assisted with remote piloting and computer piloting” caught airline pilot unions by surprise. The Air Line Pilots Association, Independent Pilots Association and Teamsters Airline Division joined in opposing the provision.

Lee Collins, president of the Coalition of Airline Pilots Associations, cites the April 17 in-flight engine failure on a Southwest Airlines Boeing 737-700 to argue against funding research into single-pilot operations. “When something like that happens, you’ve got two pilots with their hands full. You’re courting disaster,” he warns.
S-64 Composite Blade Retrofit Nears Certification

> PERFORMANCE TRIALS ARE UNDERWAY
> FLIGHT TESTS SHOW IMPROVED EFFICIENCY AND HIGHER RESISTANCE TO RESONANCE, SHUDDER

Guy Norris Los Angeles

Light tests of Erickson Inc.’s long-running advanced composite main rotor blade upgrade for the Sikorsky S-65/CH-54 heavy-lift helicopter have accelerated, with completion now targeted by late summer and certification anticipated about six months later.

The new blade is designed to significantly improve aircraft performance, particularly fuel burn and payload capability at altitude. It is also aimed at development of a single main rotor blade that can be installed on four different derivatives; the CH-54A/B and the S-64E/F.

However, testing and development of the blade has taken longer than expected. Started by Erickson and Helicopter Transport Services in 2010, the program was originally slated for certification by the end of 2016. But delays cropped up after delamination occurred in some of the initial flight-test blades and, following a set of other unspecified hurdles, some key tests were pushed back into early 2018.

“There was a series of events, malfunctions and problems with some of the blades coming out of manufacturing,” says Erickson chief pilot Randy Erwin. “We finished up strain-gauge certification for the composite blades on the S-64F model, but missed the window [for high-altitude tests] in Leadville, Colorado, and made the decision to stop and do the S-64E model.” Although delamination was noted on three blades within a few hours of starting flight tests, “the engineers worked on it and found [this occurred] only in particular blades in which the manufacturing had been different to the others,” he adds.

Blade development was carried out by Newport News, Virginia-based Advanced Technologies Inc., with some blades for flight testing produced by Composite Technology Inc., a Texas-based Sikorsky company now owned by Lockheed Martin, and others produced at a newly established composite manufacturing facility set up by Erickson in Medford, Oregon. All production issues have now been resolved, and vibration and strain gauge testing has been completed on the baseline metallic and composite blades on both the S-64E and -F helicopters.

“Now it is time for performance testing,” says Erwin. The instrumented S-64F test aircraft, which shares the same rotor head as the former CH-54B military variant, is in South America where, following low-level tests in Tacna, Peru, and high-altitude work in Cusco, Peru, it made a brief appearance at the recent FIDAE air show in Santiago, Chile. The S-64E test aircraft, which has a common rotor head with the CH-54A, is meanwhile due to conduct high-altitude tests at Leadville in June following lower-altitude work in Medford.

The new blades feature advanced airfoil technology, twist and swept tips for improved performance and extended life. Although testing is ongoing, initial performance results are encouraging, Erwin says. Despite being 8 lb. heavier per blade than the original hollow extruded aluminum rotor because of weights added for rigidity, he says the aerodynamic benefit results in a 13% improvement in efficiency in the S-64F.

“I was really shocked,” Erwin notes. During tests of the S-64F at maximum gross weight, the helicopter was brought to an initial hover at 200 ft. at a weight of a little more than 48,000 lb.—about 1,000 lb. higher than the standard gross weight—in order to reach the appropriate test condition. Adjusting for the 1,500-ft. altitude of the helipad and the 20C (68F) temperature at the time of the test, the helicopter was hovering at an equivalent density altitude of almost 3,000 ft.

“The performance charts said that we were torque-limited, meaning the horsepower the transmission would accept was far below what the engines would produce,” he says. “The charts would tell you at 9,000-ft. density altitude with a max power of 7,900 hp you should be at 46,000 lb. With metal blades, we would have been torque-limited at 82.3%, and instead we were hovering at 68% with 48,000 lb. In Peru, we are drawing new performance-imit charts.”

Aside from greater lift, the composite blades have proven to be “benign” to ground resonance, a phenomenon to which helicopters with articulated rotor systems are particularly susceptible. The blade also negates most of the “shudder,” excessive vibration, that can affect large helicopters during periods of translational lift as they move from hovering to forward flight and vice versa. The shudder is caused by the tail rotor passing through vortices shed from the main rotor. “It beats the hell out of the airframe, and the heavier you are, the more pronounced it is. In the [S-64] Skycrane, it is so bad that, if the pilot is not adept at staying out of it, the instrument panel vibrates so much it can be hard to read. These blades have almost completely eliminated that shudder,” says Erwin.

From a maintenance and operational tempo perspective, the composite blades are also beneficial, he adds. The spars inside the hollow metal blades are sealed to allow nitrogen to be stored inside at 10 psi. “As the blade[s] get older, over time they will fatigue and maybe crack. There is a little pressure sensor in the blade root, so if the spar vents that pressure you will see it,” he says. In addition, flights of 5 hr. or more are not permitted without checking the spar pressures. “With a composite blade you don’t need that,” Erwin notes.

Fuel burn also is expected to be reduced by the new blades, although the company, which previously forecast a 3-5% reduction, is not specifying the figures until flight tests are complete. “We are currently burning 525 gal./hr, so we are going to see a big improvement in that,” he says.
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Why Space Matters

By Sandra Magnus

I have just completed a trek in the Langtang Valley in Nepal, pictured above, a remote location by any standard. As I observed how people in such an isolated part of our planet live, I noticed some interesting things.

In a tea house at the very top of the valley, the highest elevation at which people live, I sat in the kitchen and watched our hostess prepare breakfast on a huge cast iron stove that could only have been delivered by helicopter. One evening in the dining area of another tea house, a room that typically doubles as a living area, I saw some of the family sitting on a bench in the corner of the room watching a Bollywood movie on a cellphone propped up on the table in front of them. At another tea house, I had the pleasure of enjoying a hot shower, thanks to a solar-powered water heater attached to the roof of the building.

Why do I bring these observations to your attention? Because a lot of the technology that makes daily life easier in this valley, and other remote areas of the world, came from the knowledge and advances we in the aerospace industry have made due to the demands required by pushing the human experience off the planet.

Next year will mark a half-century since we landed people on the Moon and brought them back to Earth. That monumental achievement sparked interest in space exploration, both manned and unmanned, around the world. That inspiration fueled huge investments in research and technology, not only in the U.S. but, as time passed, globally, as we as a species aimed our ambitions upward and outward.

However, from the start, we have had endless debates about the importance of a space program. One of the main arguments against what is perceived to be the high cost of space exploration is that resources would be better spent seeking solutions for the many problems here on Earth.

The two goals are intertwined and cannot be separated; advancing one automatically advances the other. While the fact that we have had a space station circling the Earth for more than 18 years is irrelevant to the people of the Langtang Valley, that they have efficient solar cells to provide them with electricity to heat water is not. Even though they are unaware of the hundreds of satellites in orbit around the Earth, it does not change the connectivity and information that those satellites—and the technology derived from their development—bring to the valley. The list goes on, not only for the impact on people in Nepal but in all remote areas of the world.

The trajectory for innovations used by those who live in the Langtang Valley started over 50 years ago with the decision to tackle the space frontier. I am proud that we, a country with rich resources, have chosen to continue to invest in pushing the boundaries of human knowledge and existence. It is an activity that benefits people everywhere. I fully hope we will continue to be a driving force, providing the inspiration and vision for expanding human exploration of our Solar System and to pursue that goal in a globally collaborative manner that will optimize the advancements for all. Human expansion into space is changing our world and making a positive difference in people’s lives, immediately and over time, in ways big and small.

Sandra Magnus is the executive director emeritus of the American Institute of Aeronautics and Astronautics. She flew on three space shuttle missions, including the shuttle’s final flight in 2011, and later served as deputy chief of the Astronaut Office at NASA.
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However, from the start, we have had endless debates about the importance of a space program. One of the main arguments against what is perceived to be the high cost of space exploration is that resources would be better spent seeking solutions for the many problems here on Earth. Well, as I walked the length of the Langtang Valley, observing life there, the answer to that eternal round of debates was strikingly obvious. By pushing outward and conquering the challenges related to operating on the edge of what humans can do, we are helping solve problems that exist on Earth.

The two goals are intertwined and cannot be separated; advancing one automatically advances the other. While the fact that we have had a space station circling the Earth for more than 18 years is irrelevant to the people of the Langtang Valley, that they have efficient solar cells to provide them with electricity to heat water is not. Even though they are unaware of the hundreds of satellites in orbit around the Earth, it does not change the connectivity and information that those satellites—and the technology derived from their development—bring to the valley. The list goes on, not only for the impact on people in Nepal but in all remote areas of the world.

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