July-August 2015

AEROSPACE AMERICA

NASA's $14 BILLION DECISION

Who will ferry cargo to ISS next?

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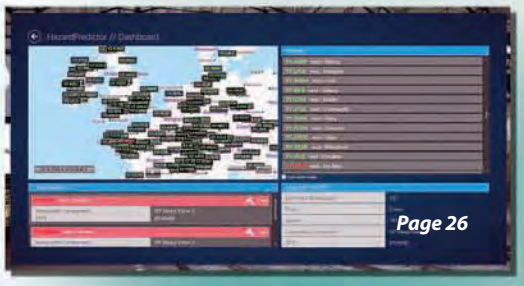
A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

AEROSPACE AMERICA

July-August 2015



DEPARTMENTS

FEATURES

BULLETIN

ON THE COVER
The five cargo vehicles competing for the $14 billion NASA contract (clockwise from top left): **Cygnus** (Orbital ATK); **Dream Chaser** (Sierra Nevada Corporation); **Jupiter and Exoliner** (Lockheed Martin); **Dragon** (SpaceX); **CST-100** (Boeing)

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AIAA
Shaping the Future of Aerospace

Editor's Notebook

More aviation cybersecurity, please

Most articles I read outside of Aerospace America invariably turn my thoughts to matters of aerospace. That was the case with a feature article in Wired magazine about the FBI's 2013 takedown of the San Francisco computer whiz who clandestinely ran the Silk Road digital drug bazaar.

Ross Ulbricht is depicted as a seemingly normal young man who enjoyed hanging out with his friends at the beach, playing drums, and going to the park with his housemate and her Chihuahuas. When he booted up his laptop, his online alter ego, The Dread Pirate Roberts, would view proof-of-death photos of the enemies killed by hit men he hired online (The photos were apparently fakes).

The Silk Road case shows that otherwise normal people will do things in cyberspace that they would never do in the physical world. Maybe bits and bytes provide insulation from feeling the human toll of one's actions, or maybe computer code simply gives physically weak bad people the power to do nasty things they're not biologically equipped to do. Whatever the case, chances are, somewhere out there is a person who in real life would never spring from an aisle seat to hijack an airliner or stand on a hillside and launch a shoulder-fired rocket at one, but who might try the same via cyberspace.

The aviation industry and governments around the world are aware of these digital risks and many others. When I think about our coverage of aviation advances in Aerospace America, I see a thread of Tom Clancy-worthy vulnerability running through these technologies. Once unmanned planes are enlisted against wildfires, it's conceivable that a hacker will try to seize one in skies crowded with giant airtankers, just to see what happens. Researchers are hard at work on sense-and-avoid technologies for unmanned planes, and the lure of trying to spoof this technology might be too much for your average hacker to bear. Or, imagine a hacker breaking into an airliner's flight control computer and daring a pilot to realize that his plane is headed the wrong way before it's too late.

The industry is acting. AIAA released its "Framework for Aviation Cybersecurity" in 2013, and last year seven major airlines and some aircraft manufacturers created the Aviation Information Sharing and Analysis Center, or A-ISAC, in Annapolis Junction, Maryland.

Those are good starts, but experts rightly warn that cybersecurity has to be improved widely, including in the FAA's Next-Generation air traffic control plan and also internationally.

There is much more work to do, and the Silk Road case reminds us that the problem is not one to defer until tomorrow.

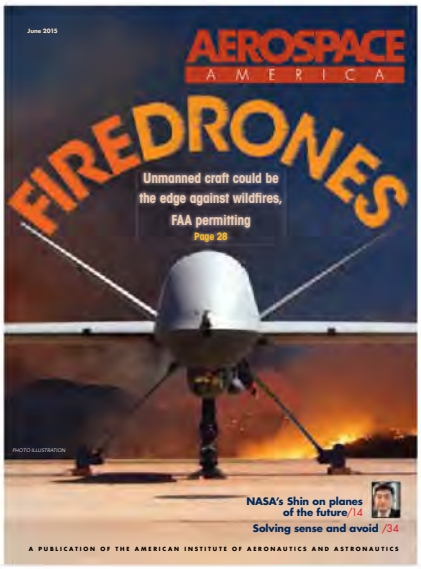
Ben Ianno tta
Editor-in-Chief

Fighting wildfires with drones

Thanks for your "Fire Drones" in Aerospace America [June].

As a former U.S. Air Force pilot and attorney in aviation and aerospace, including several years representing air-traffic control interests, I am very interested in the subject matter in your article. That's the answer to fighting forest fires. And the idea of fighting fires at times when no air carriers or other aircraft are in area is the answer for safety of all concerned. Finding fires before they spread would be ideal, perhaps best accomplished, ultimately, by unmanned observers in the sky, with careful monitoring.

Thanks for your timely article.



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All letters addressed to the editor are considered to be submitted for possible publication, unless it is expressly stated otherwise. All letters are subject to editing for length and to author response. Letters should be sent to: Correspondence, Aerospace America, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344, or by email to: beni@aiaa.org.

Events Calendar

12–16 July
International Conference on Environmental Systems
Bellevue, WA
Contact: Andrew Jackson, 806.834.6575 Andrew.jackson@ttu.edu www.depts.ttu.edu/ceweb/ices

25–26 July
The Application of Green Propulsion for Future Space;
Advanced High Speed Air Breathing Propulsion
Orlando, FL

27–29 July
AIAA Propulsion and Energy 2015 Forum;
51st AIAA/SAE/ASEE Joint Propulsion Conference;
Orlando, FL

30–31 July
Business Management for Engineers;
Hybrid Rocket Propulsion
Orlando, FL

9–13 August
2015 AAS/AIAA Astrodynamics Specialist Conference
Vail, Colorado
Contact: Dr. W. Todd Cerven, william.t.cerven@aero.org, www.space-flight.org/docs/2015_astro/2015_astro.html

29–30 August
Introduction to Space Systems
Pasadena, CA

31 August–2 September
AIAA SPACE 2015
(AIAA Space and Astronautics Forum and Exposition)
Pasadena, CA

Ukraine's Antonov looks urgently for partners

Antonov hopes that a recent deal with Saudi Arabia to build AN-32 light transport multipurpose aircraft could help recharge interest in Ukraine's dwindling domestic aircraft industry.

U.S. Air Force

The May announcement that Ukrainian aircraft manufacturer Antonov had struck a deal with Saudi Arabia to develop and build a new version of the AN-32 passenger and cargo aircraft was a hopeful sign for those rooting for the revival of Antonov's moribund domestic business even amid the conflict with Russia. But despite the Saudi deal and an earlier agreement with a Chinese company to jointly develop a new AN-178 military cargo plane, analysts are cautioning that Antonov's revival remains an open question.

Antonov — once a symbol of Ukrainian industrial prowess and which has produced more than 22,000 aircraft since 1942 — is, according to The New York Times, delivering barely 10 aircraft a year. The 2014 conflict between the Kiev government and Russian separatists left the Ukrainian economy in shambles, and the International Monetary Fund is projecting the former Soviet state's economy to shrink by 9 percent and for inflation to hit 46 percent by year end.

With orders from Russia, its main customer, gone, Antonov urgently needs foreign partners to sustain its business, experts say, though the government will be keen to see it survive. But these experts say a mass of domestic orders appears unlikely any time soon, given the economic woes and the military situation.

The venture with Saudi Arabia's King Abdulaziz City for Science and Technology was borne out of Antonov's efforts in the past year to seek alliances with the Arab kingdom as well as with India and China to help finance and develop a line of civil and military aircraft. The Antonov's current product lineup includes the AN-148/AN-158 family of regional passenger aircraft; the AN-178 transport, a military cargo version of the AN-148; and the AN-32, AN-70 and AN-124 cargo aircraft.

The agreement to build the AN-32 will be the first commercial aircraft to be designed and built in Saudi Arabia. The aircraft, with Pratt & Whitney engines and Honeywell avionics, is meant to fill Saudi Arabia's need for small cargo planes for both civilian and military sectors.

Despite the dearth of deliveries, Antonov's order books are slowly filling up. They include 10 AN-178s slated for Silk Way Airlines of Azerbaijan, as well as 90 orders for the A-148/AN-158 passenger aircraft and 50 more orders for special mission variants of the same aircraft from several customers. Antonov also has orders for 14 aircraft — nine AN-148/AN-158s, two AN-70s, two light patrol aircraft and one light transport passenger aircraft — from the Ukrainian government.

Still, skepticism lingers that Antonov's new partnerships will be enough to reverse its fortunes.

"It's far from clear how a Ukrainian company, or any defense company, can sell planes abroad without a home market order," says Richard Aboulafia, vice president of analysis at the Teal Group, a consulting firm in Fairfax, Virginia. "Even if there is a domestic buy, how will export customers be reassured about product support for what would likely be an orphan aircraft?"

Antonov executives are aware of the skeptics but say interest in its aircraft remains high. The company, after all, built the world's two largest aircraft — the AN-225 and AN-124. Antonov's most recent model is the AN-178, a twin engine military cargo aircraft to compete with the Embraer KC-360 for the AN-12 and C-160 replacement market and which flew for the first time in May. And despite news reports that no more AN-124s will be produced, Antonov's head of marketing told Aerospace America by email that a new version of the AN-124 is under development: "At present, serial production of the AN-124-200 new cargo aircraft is being resumed," Viktor Konarev says, adding it will have modernized airframe, glass cockpit, full-authority digital engine control and other features.

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India's year of expansive space programs

India has developed one of the world's most advanced satellite-based telemedicine networks, connecting patients in remote communities with doctors in urban areas via high-speed Internet and telecommunications systems. The country has also relied heavily on its Earth-observation satellites to track hurricanes, cyclones and patterns of environmental degradation. It also has used communications satellites to link medical specialists to patients in far-flung rural areas and to educate students.

But now, India is making a major push to use satellites to expand its military capabilities, as part of the next stage of what many experts see as a possible arms race with China.

In May the Indian Navy began linking all its ships via a satellite-based video-conferencing network to enable on-board medical teams treating wounded sailors at sea to consult medical specialists throughout India. That has been made possible by the August 2013 launch, on an Ariane 5, of the multi-band 2,650 kilogram GSAT-7 Rukimi, the first exclusive military satellite from the Indian Space Research Organization, or ISRO.

Indian Space Research Organization

India's Geosynchronous Satellite Launch Vehicle Mark 3 lifts off carrying the Crew Module Atmospheric Re-entry Experiment.

In addition, the space organization has a new range of heavy launchers — the Mark 3 version of the geosynchronous satellite launch vehicle, GSLV — about to enter the market. It also has new communications and Earth-observation satellites in development, a global navigation satellite system which will be operational by the end of 2015, and an ambitious scientific program that includes a mission to the moon with a lunar rover within three years.

In July, the ISRO is scheduled to launch the next in the series of military communications satellites — the 2,200 kilogram GSAT-6 on a Mark 2 Indian geosynchronous satellite launch vehicle from its spaceport at Sriharikota in Andhra Pradesh. This can carry a payload of up to 2.15 metric tons into a geosynchronous transfer orbit. Previously in December 2014 the ISRO made the first successful test flight of the Mark 3 version of the GSLV, built to take 4 metric tons into a geosynchronous transfer orbit or 10 metric tons into a low earth orbit.

The Mark 3, with a third-stage cryogenic engine developed and built in India, will make the ISRO self-sufficient in the launch of heavier satellites, such as those required for future military communications and observation spacecraft, say industry experts. On its first flight the Mark 3 carried an unmanned astronaut crew module, an experimental version of ISRO's future three-person Orbital Vehicle.

Later this year military and civil customers will be able to start using position location services with India's version of the U.S. global positioning system. The fourth of seven Indian Regional Satellite Navigation System spacecraft was launched in March on an ISRO polar satellite launch vehicle. The constellation will eventually comprise four satellites, with three spares, to triangulate a user's position within an area encompassing India, its surrounding seas and neighboring countries.

Also later this year will be the launch of the Reusable Launch Vehicle-Technology Demonstration Program, a scaled down, test-bed version of a space shuttle which the ISRO wants to operate within the next decade. The mission will include a hypersonic flight test.

Meanwhile the IRSO's Mangalyaan ("Mars craft" in Hindi) Mars orbiter mission, launched in November 2013 on top of an ISRO polar satellite launch vehicle, is circling Mars looking for methane, as part of the search for life on the planet.

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Broad agenda seen for China's moon missions

China, in the view of some American space experts, seems determined to send humans to the moon. If so, evidence suggests Chinese engineers might want to bring their astronauts home via the same kind of "skip reentry" technique that the U.S. plans to use for its Orion capsules.

U.S. space experts have been parsing a technical overview published in April by Chinese space engineers, describing the country's 2014 circumlunar test mission, called Chang'e 5-T1, in which an unmanned capsule reentered and touched down in China's Inner Mongolia Autonomous Region.

The paper, "Technical Advancements and Significance of Circumlunar Return and Reentry Spacecraft," appeared in the journal, Science China: Technological Sciences, published by the Chinese National Academy of Sciences. It provided previously unreleased details, including the fact that China used a semi-ballistic, skip reentry technique, in which a capsule makes successive skips off the atmosphere, with each skip slowing the capsule and dissipating reentry heat. China guided the capsule to a precise reentry corridor and a landing at Siziwangqi in Inner Mongolia, according to the paper.

By contrast, Apollo capsules plowed directly into the atmosphere. NASA encoded a skip reentry capability in the flight software as a back up in case of bad weather over the primary splashdown site, but the technique was never used operationally. Orion capsules will have a more advanced guidance and control strategy to implement this skip capability.

China, the paper said, also will employ the skip reentry to bring a lunar sample home from an unmanned mission it plans to launch in 2017.

China's use of skip entry is relatively complex, says Michelle Munk, an entry, descent, and landing principal investigator at NASA's Langley Research Center in Virginia.

"From my perspective, it's more complex than a simple ballistic entry. Depending on the precision of the landing they want to achieve, the guidance, navigation and control has to be fairly sophisticated," Munk says.

In the view of another American expert, the evidence suggests a desire for more than a lunar sample.

Associated Press/Xinhua

China launched an experimental unmanned spacecraft atop a Long March 3C to fly around the moon and back to Earth in preparation for the country's first unmanned return trip to the lunar surface in 2014.

The 2017 mission "shows that China is serious about developing a complete cislunar-lunar flight capability," says lunar scientist Paul Spudis. "They are shooting for cislunar space dominance and, at this rate, will likely achieve it," he adds.

Spudis was deputy leader of the science team for the Clementine probe that NASA and the Pentagon sent to image the moon in 1994. It's clear, Spudis says, the Chinese "are certifying the architecture for a human mission to the moon."

China, however, describes its plans as more limited.

China "has the ability to achieve the manned lunar landing but it has no plan to do it," the country's Xinhua News Agency quoted Zhou Jianping, chief designer of its manned space program, as saying earlier this year. Zhou's program has been limited to low-Earth-orbit missions.

"With China's current technologies of manned space flight and moon probe, we have the technology basis to realize the manned lunar mission," Zhou reportedly said.

According to the paper's authors, "The complete success of this mission indicates that the key technologies of circumlunar return and reentry have been broken through in China."

The paper also reports seven new kinds of lightweight thermal protection material were developed for the capsule, promoting the development and use of composite material in China.

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China Aerospace Science and Technology Corporation

After nearly 196 hours of flight, China's Earth-to-moon-to-Earth reentry capsule parachuted into Siziwangqi in Inner Mongolia on November, and was recovered and delivered to Beijing.

Addressing risk of brain damage in spaceflight


Brookhaven National Laboratory

A physicist checks cabling on the radiation beam line, an apparatus at the Energy Department's Brookhaven National Lab in New York. The beam line transmits charged particles to irradiate mice for NASA and simulate what astronauts would experience in deep space.

The research article, "What happens to your brain on the way to Mars," earned some sensational headlines when it was published in May on a website run by the American Association for the Advancement of Science. Smithsonian.com declared, "A trip to Mars could give you brain damage." The Space Foundation ran the headline in its news roundup.

The headlines weren't wrong. NASA-funded researchers set out to learn whether deep-space radiation would have a different effect on the brain than radiation on Earth and, if so, what those effects might be. They irradiated mice at Brookhaven National Lab on Long Island and six weeks later put them in pens with toys. The irradiated mice showed less curiosity to new toys in the pen or new placement of familiar toys. Researchers later dissected the mice brains and found that the normally thick network of neuron dendrites in their medial prefrontal cortices had thinned compared to control mice.

Charles Limoli, professor of radiation oncology at the University of California at Irvine and senior author of the study, likened the effect to pruning the branches of a tree. "Perhaps most concerning to NASA is that we have no evidence that these changes ever resolve," he says.

The report's findings raise a serious concern, but judging by comments from researchers, it seems unlikely to derail NASA's aspirations to send astronauts to Mars sometime in the 2030s.

Limoli says the findings need to be viewed in context.

"The astronauts, when they get in the car, they expose themselves to higher risk of dying than when they go into space," he says. "Everything has to be taken in perspective." The ultimate goal of this and other research is to come up with possible solutions to whatever the damaging effects might be, possibly in the form of pharmaceutical therapies, he says.

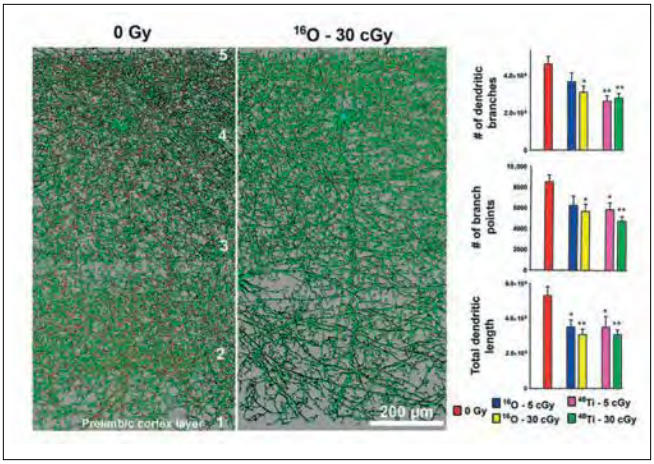
NASA in a prepared statement says "these studies and future studies will continue to inform our understanding as we prepare for the journey to Mars." In fact, earlier this year, as the researchers were heading toward publication, NASA announced a new $9 million grant to Limoli's team for more mice experiments to study early and long-term effects of galactic cosmic radiation on the central nervous system.

Just how much can be learned from mice remains an open question. Mice are far from ideal surrogates for astronauts, not least because the animals have relatively short lifespans, And primates haven't been used for radiation experiments since the 1990s because of animal welfare concerns.

It's costly to generate particles to simulate deep space. So, mice are typically irradiated in one session, whereas astronauts would experience lower levels of radiation that would be cumulative over the three-year duration of a Mars mission. Astronauts also would return to Earth to live for decades, but mice don't live long enough to assess impacts for that length of time.

Those factors point to "the biggest hole" in all of the research published to date, says Dr. M. Kerry O'Banion of the University of Rochester, who was not involved with the recent mice experiment but whose 2012 study with mice linked deep-space radiation exposure to increased risk of Alzheimer's disease.

It's "recognized that radiation and brain don't mix," but how bad and long-lasting is the damage? "If the [human] brain sustains such damage — but at a very low level — are there intrinsic repair mechanisms or plasticity of the brain? Or ways that it can recover if you have a slow chronic problem? And people in neuroscience will have different answers for that," he says.



American Association for the Advancement of Science

Brains of mice before (left) and after exposure to simulated deep-space radiation showed a thinned network of neuron dendrites in their medial prefrontal cortices. The mice were genetically engineered to express green fluorescent protein in certain neuronal subsets.

Natalia Mironova
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HondaJet
with uncommon engine placement nearing debut

HondaJet's unusual engine placement atop the wings has some people wondering if it might start a design trend.

When Honda Aircraft Co. flew its HondaJet on a marketing tour through Japan and Europe in May after earning a preliminary FAA approval, the curious public looked first for the plane's most-intriguing feature: engines mounted atop the wings.

The FAA is expected to issue its final certification soon, which could trigger deliveries of the first of more than 100 of the $4.5 million jet on order.

The plane is the culmination of more than two decades of personal nurturing by Honda Aircraft President and CEO Michimasa Fujino. The four- and five-passenger business jet is the first from Honda Aircraft. The first 20 are in production in Greensboro, North Carolina. The plane competes in the very-light-jet class against Embraer SA and Cessna Mustang, among others. Honda says the jet cruises at 420 knots at 30,000 feet, 10 percent faster than published speeds for Embraer and Cessna. And because it doesn't need bracing through the fuselage to support engines in the rear, Honda says it was able to make the cabin bigger than it would have been.

Though HondaJet may be the fastest in its class right now, that could change with the announcement last October by Sierra Industries that it will offer the new GE Honda/HF120 engine for Cessna retrofit upgrades.

HondaJet's engine placement is just a part — albeit a key part — of a design that has benefited from advances in computational fluid dynamics and wind-tunnel testing.

The engines-on-top decision was "not one silver bullet for performance. It's all things in the system," says Rich Wahls, associate head of configuration dynamics at NASA's Langley Research Center. Wahls was part of a HondaJet test in 2005-07, when the company bought time in Langley's National Transonic Facility .

Wahls says the jet's composite fuselage reduces weight, part of the reason why the HondaJet burns 17 percent less fuel than Cessna, according to Honda. Wahls says the air flow on the slightly bulged forebody and aluminum wing reduces drag, as does the orientation of the nacelle on the pylon, and the contouring of the two. "I think what they've been able to do through very detailed shaping of the pylon/nacelle is not only avoid a penalty on drag, but gain a system level benefit," Wahls says.

Minimizing drag — enemy of speed and stability — and maximizing airflow were critical to making the uncommon engine placement pay off. The HondaJet's engine intakes are at the wing's trailing edge, and pylons are shaped and slightly angled. The result is channeled airflow and a reduced chance of shock.

"All of that has to be tailored so as to not get those shocks, so you can get low drag," says Larry Leavitt, who recently retired as NASA Langley's chief engineer. "They've done that. You look at those nacelles and the pylons they sit on, and it's clear that it's all very asymmetric and tailored for the transonic regime they're in."

The engines-over-wing concept is not new; early seaplanes had them, and so does the Boeing X-48 blended-wing body research aircraft for NASA. The design, however, long ago fell out of favor. But not out of mind. NASA has studied over-the-wing engine configurations on transport airplanes.

"Sometimes it's a matter of technology catching up with ideas or of fusing the right ideas together to get the right overall system benefits," Wahls says. "Then you have a winner."

Wahls says the HondaJet's engine placement could change some minds.

"You would probably find people who say it's better and people who are still skeptics," he says. "But I think they've made it work and it may start a trend. Others may take another look at this installation because of the HondaJet and find new and practical benefits. We'll see."

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Connected aircraft in era of Uber and Airbnb

With Wi-Fi available on more passenger jets, flight attendants swiping credit cards for meal purchases and pilots viewing airport taxiway maps on iPads instead of paper, today's aircraft may seem a picture of perfect connectivity.

In reality, aircraft, airlines and the aviation industry are barely getting started. That was a dominant theme at June's Global Connected Aircraft Summit in Chantilly, Virginia. Shifting to truly ubiquitous connectivity, speakers said, will demand more bandwidth, new software, new networks, and more secure and reliable connections.

Today, airplanes and airlines tap only a fraction of the potential networks and services in cyberpsace. More connectivity could, for example, enable pilots to make more-precise decisions about bypassing bad weather or let airlines pinpoint and sell seats that might otherwise go empty. Truly pervasive connectivity, combined with big-data analytics software, speakers said, could revamp the aviation industry in the same profound way that Uber and Airbnb have upended the taxi and hotel businesses.

Howard Charney, senior vice president of Cisco, the network-equipment maker, talked about aviation and "the Internet of everything," the cyber industry's term for installing simple electronics on objects to connect them to the digital world. Less than 1 percent of the physical world is connected, Charney said, leaving untapped potential not just for aviation but for everything from health care to agriculture to financial services. In Charney's vision, sensors and predictive analytics in aviation would reduce operating costs, improve services and boost revenue.

For instance, a sensor could alert the crew when the trash compactor needs emptying. Or instead of asking "chicken or beef?" flight attendants would know to offer the passenger in E3 the pasta entrée, based on the passenger's previous in-flight meal orders.

"It sounds intrusive," Charney acknowledged, adding that much online privacy is already compromised. "Every time you go on the Internet, we know who you are."

In and out of the cabin, extracting useful information from hundreds of petabytes of data generated each year from flights in the United States alone, Charney said, can bring "seismic" change to an industry whose operating margins perennially hover between black and red.

"Your profits would disappear — or it could double, if you are really smart," Charney said.

Andrew Kemmetmueller, vice president of airline applications for Chicago-based Gogo, which provides inflight phone and Internet services, pinpointed aircraft avionics as a ripe area for connectivity. "Smart" aircraft systems — in which machines communicate with each other — could streamline engine and aircraft monitoring, allow for remote data retrieval and reduce the need for hardware and power aboard the aircraft.

Kemmetmueller said many ways also exist to leverage advanced connectivity aboard aircraft. In the passenger cabin, instant credit authentication would enable airlines to sell pricey duty-free goods on board with minimal risk of fraud. That would require a secure direct link to a network from the plane.

A challenge for airlines is to figure out how to make investments in new avionics, software and other technology pay off. United Airlines, which is scheduled to complete satellite Wi-Fi rollout throughout its fleet by the end of this year, offers the service not so much as a money maker but "as cost of doing business," said Deborah Lee, United's program manager for inflight Wi-Fi and entertainment, who spoke at the summit.

Kemmetmueller noted it was only a decade ago, in March 2004, that Lufthansa debuted the world's first inflight high-speed broadband Internet access. Provided by Connexion by Boeing, it used cables and wireless local area network to link passengers to an on-board server, which in turn was connected to a pair of phased-array antennas on top of the fuselage to receive satellite signals. Boeing pulled the plug on Connexion in 2006, citing lack of demand.

United Airlines

United Airlines gave iPads to United and Continental pilots in 2011 to replace paper flight manuals. By the end of this year, United says it will have Wi-Fi connection available aboard all its aircraft.

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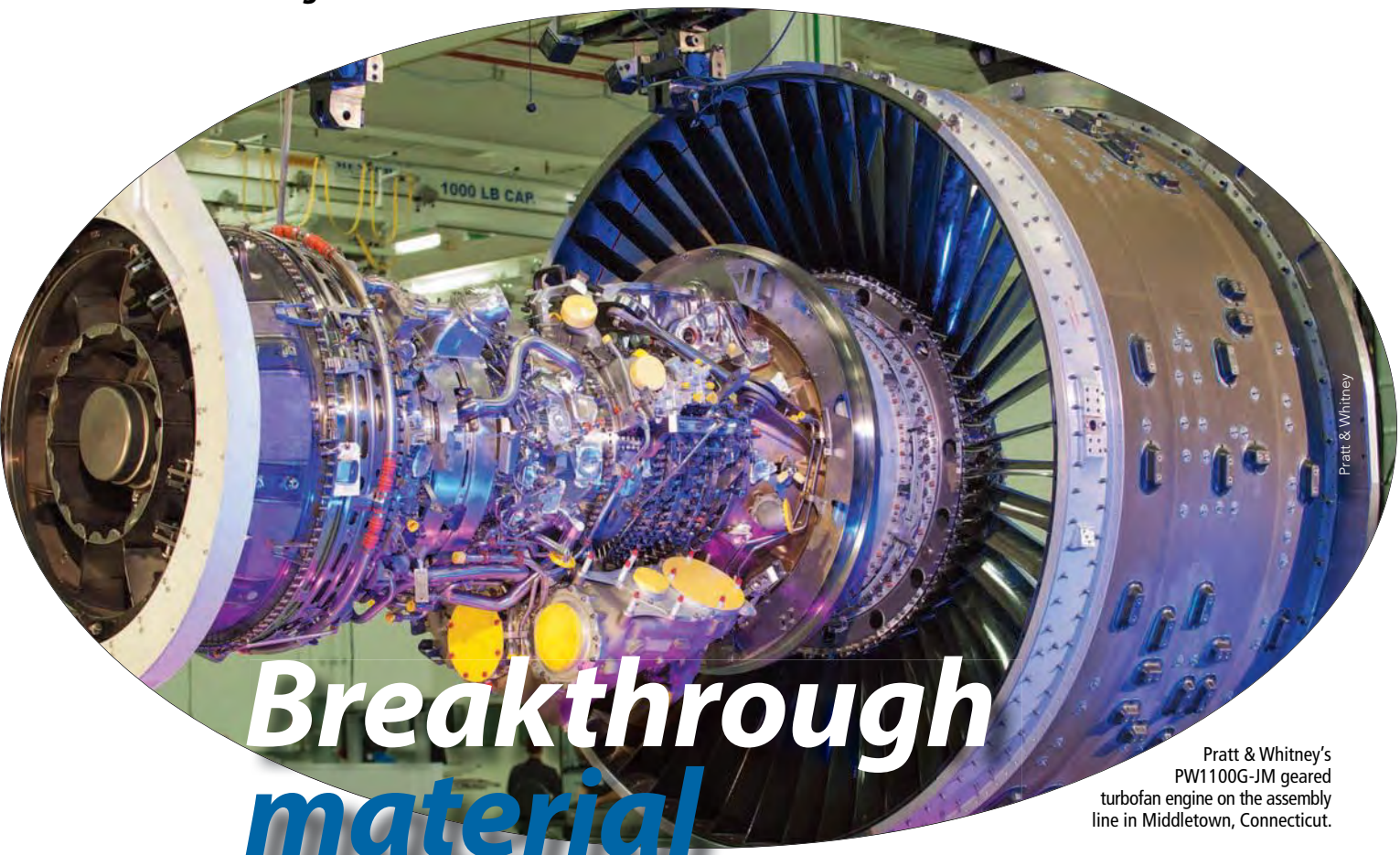
Jet engine designers have long wanted to take advantage of the compound titanium aluminide, which combines the properties of ceramics and metals. Standing in the way were questions about the brittleness of the material and the ability to make parts with it at a reasonable cost. Henry Canaday explains one team's eight-year effort to solve those problems and meet Airbus' demand for a more fuel-efficient engine.



Pratt & Whitney

Breakthrough material

Pratt & Whitney's PW1100G-JM geared turbofan engine on the assembly line in Middletown, Connecticut.

When Airbus' first A320neo is delivered to Qatar Airways later this year, it will be powered by two Pratt & Whitney engines whose fuel efficiency was achieved in part by utilizing an unusual titanium aluminide, or TiAl, compound in a section of the engine's complex machinery.

Aviation engineers have been intrigued by titanium aluminide because it does not deform or "creep" as easily as metal and it is lightweight. The downside is that the molecular structure resembles a ceramic more than a metal alloy, making it brittle in some scenarios with poor ductility, meaning it can't be easily heated and pounded into complex shapes.

This is the story of how engineers and other specialists at MTU Aero Engines in Munich, partnered with Pratt & Whitney eight years ago to defeat these challenges to the satisfaction of the European Aviation Safety Agency. Last year, the safety agency approved the engines as one of two models available on new A320neo aircraft, the fuel-efficient "New Engine Option" version of the widely sold Airbus narrowbody.

Innovating

The story begins a little more than a decade ago, when fuel prices were rocketing and calls were growing to cut carbon emissions from jets. Pratt & Whitney set out to make a more efficient engine by addressing a design limitation in conventional engines. On most engines, the front fan and the compressor blades that deliver air to the fuel combustor must

turn at the same speed, one that is optimal for neither. That's because each is attached to a shaft that's rotated by the force of combustion gases pushing through a series of turbo disks and blades and out the back of the engine. Spinning the compressor blades faster would compress the air more efficiently, but engineers can't do that because the tips of the front fan blades would spin at dangerously supersonic speeds.

Pratt & Whitney engineers came up with an innovation to avoid that compromise. It is an innovation that in its A320neo incarnation requires titanium aluminide. The Pratt team decided to place a gear between the turbine shaft and the front fan so they could turn the compressor blades at their optimal speed, and slow the large, front fan to a safe speed.

"The gearing lets us make the fan larger and more efficient, and we can also design the turbine more efficiently. We optimize them separately," explains Pratt & Whitney's Mary Colby, manager of innovation and technology. The result was a new line of Geared Turbofan engines, or GTF for short. To meet its 15-percent fuel-savings goal for the A320neo, Pratt decided on three fast-rotating compressor stages, instead of five slower ones on the V2500 engines it makes for conventional A320s. Fewer stages reduced the weight and the part count required for compression, but each stage rotates twice as fast as those on the V2500. Rotating the shaft that fast increased the centrifugal force on the blades, shaft and disks. That was OK on the smaller GTFs, because the parts could be beefed up , but it was problematic for the larger engine Pratt envisioned for the A320neo. That's where the titanium aluminide comes in. Engineers chose it for the rear blade row in the turbine of the A320neo GTF engine, the PW1100G-JM, because it is 50 percent lighter than nickel alloy. A lighter material eased the centrifugal force on the shaft and disks, and engineers did not need to increase their weight.

TiAl costs more than nickel alloy, but Pratt and MTU calculated it would be worth the higher upfront cost. "Achieving half the weight [in blades] was really important" for achieving the A320neo's fuel efficiency, says Wilfried Smarsly, a materials Ph.D. in MTU's advanced materials unit in Munich. "No other technology, design, process or material could make that big an impact."

The result is an engine with a compact, fast-turning compressor in the core that maintains combustion by siphoning relatively little of the airflow produced by the unusually large, slower-turning front fan. Engineers always want to preserve as much of that airflow outside the core as practical, because the fan cleaves the air like a propeller and generates thrust more efficiently than the core, whose main role is to convert combustion energy to kinetic energy. The relationship between the overall airflow and the flow in the core is expressed as the bypass ratio. The PW1100G-JM has a favorably high bypass ratio of 12.5 to 1, more than

The new Airbus A320neo, slated to enter service later this year, has a Pratt & Whitney engine with an unusual material.

Airbus

double the ratio of V2500 engines on some current A320s.

Getting down to work

Smarsly assembled a team of 30 MTU engineers in 2007 to work on the high-speed, low-pressure turbine for the new engine. Some were experts in designing structures, others were skilled at manufacturing, milling, quality control, marking and cleaning. Smarsly's budget was generous, partly because titanium aluminide would require testing 10 times more than other materials.

MTU, which had made parts for Pratt & Whitney engines since the 1970s, had its own techniques for producing metal alloys, but working with titanium aluminide was a much trickier challenge.

Due to TiAl's poor ductility, engineers once thought it might be impossible to forge turbine blades by the usual method of heating the material and bending it to shape. As it turns out, TiAl can be forged when the material is within a precise temperature range. One of MTU's partners, the Department of Physical Metallurgy and Materials Testing at the University of Leoben in Austria, calculated the optimum temperature range for forging the material, and this enabled forging with conventional machines with one important upgrade. Existing furnaces at supplier sites lacked sufficient temperature sensitivity for precise control, so MTU invested in upgrading them and training supplier employees to run these upgraded furnaces.

"That should be simple, but it was critical," Smarsly says.

Brittleness was the other big challenge. After metal blades are forged, they must be machined into final shape. MTU realized that a TiAl blade had to be machined to a more precise shape than a comparable metal blade to cope with the brittleness. "Tighter tolerances control stress distributions more precisely," explains Smarsly. "In Germany we have suppliers who can do that. It's expensive, but it works. And I don't think you can find such suppliers anywhere else."

Smarsly says there were also emotional challenges in working with an unusual material. The engineers who would design the new blades feared their brittleness and worried that there would be component failures. Lots of tests would be required to build confidence.

Smarsly's team moved fast. In the first two years, they defined the precise chemical composition and the raw-material production process for their version of TiAl. A breakthrough came in 2010, when MTU shook and spun the blades in Munich.

"We verified we could handle brittleness, the biggest issue," Smarsly says.

Then, in 2012, MTU tested TiAl blades in an engine, although not yet the PW1100G-JM and at speeds and temperatures a little higher than blades would run in the Pratt & Whitney engine. That nevertheless established the blades' reliability and useful life.

In 2013, TiAl blades were tested in a Pratt & Whitney engine in the United States. The following year the European Aviation Safety Agency certified the PW1100G-JM engine and the TiAl blades for use on the A320neo; this year MTU and Pratt & Whitney began production.

Production

Getting to production on such a tight schedule took more than luck. MTU's Marcus Woehler and his colleagues had to choose final suppliers and production techniques and set the specifications and tolerances for production parts. It was 2011, and by then MTU had a full set of technology demonstration TiAl blades that the team had to transform into a product that could fly safely and economically. The blades had the general geometry required, but MTU had to define the tolerances, the quality and the reliability needed to operate in engines for 10 years or more.

A supply chain was set up to produce blades in small quantities. Next, MTU had to choose the specific firms that would be used for the high volumes required for the A320neo.

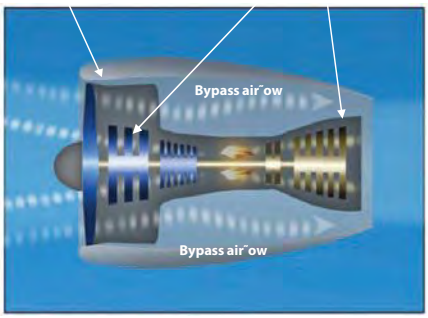
The selection process involved choosing the best manufacturing techniques for the geometry of the production blades. Different methods could be used at each step: making the raw material, forming it into basic shapes and finishing it precisely. Each method had its advantages and disadvantages.

The team settled on three tech-

STEP CHANGE IN EFFICIENCY

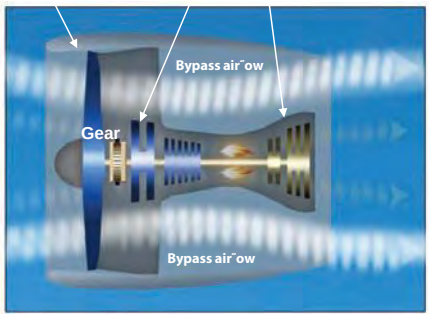
Pratt & Whitney engineers put a gear between the shaft and the front fan of their Geared Turbofan engines (right). This lets them rotate the large front fan at a slower, more-efficient speed, increasing bypass airflow, while turning the compressor at a faster, optimal speed.

Conventional Turbofan



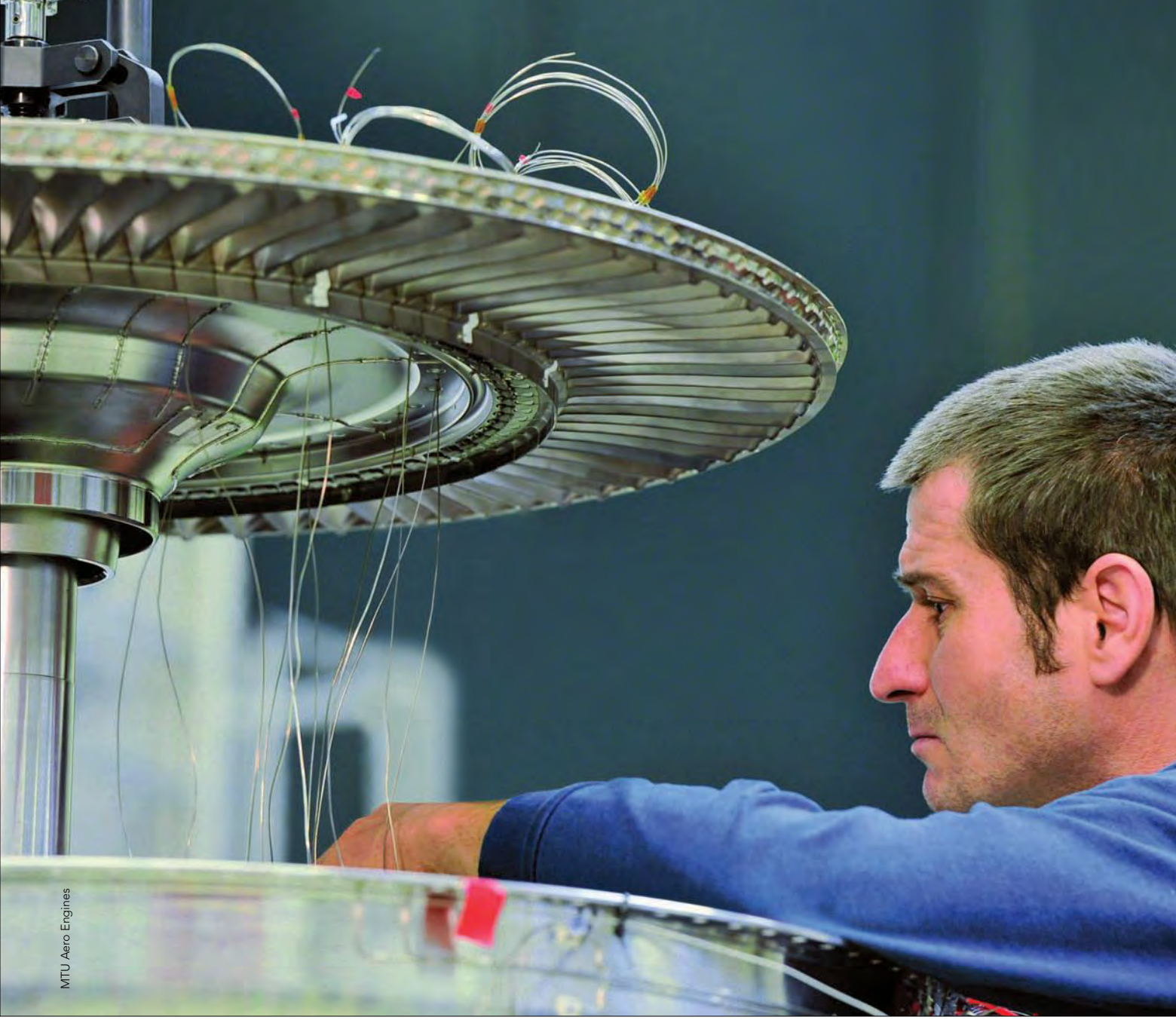
Incremental improvement

Geared Turbofan engine



Step-change improvement

Pratt & Whitney



An employee of MTU Aero Engines in Munich assembles a turbine containing the company's titanium aluminide ceramic-metal material.

niques. Melting heats and combines the metals at very high temperatures. Forging shapes the basic parts using compressive forces from a hammer or die. Milling uses cutters to remove material from the forged part to give it the exact shape required.

Forging was chosen over casting because it yields stronger blades. Milling was chosen over grinding, which uses an abrasive wheel for cutting.

"Different methods were investigated, and we made our decisions based on quality and cost," Woehler says. "We also chose suppliers that were capable of meeting the volumes for A320neos."

Woehler had to set specification limits for quality assurance on these production engine parts. Production specifications had to be set for the chemical and phase compositions of the TiAl material and for deviations allowable in the geometry of the blades. These limits had to recognize cost as well as quality over the long haul of a production engine.

To counter brittleness, TiAl blades are made to very tight specifications for shape and composition, but they are attached to a rotor disk made of conventional material at traditional tolerances. The manufacture of these disks is very difficult to change, and MTU is still trying to deal with this challenge. The issue is not safety or performance of the TiAl blades, but how frequently the assemblies must be inspected and possibly repaired — thus how much maintenance will cost.

"We want to have a robust design," Woehler stresses.

Meanwhile, MTU is considering using TiAl in other engine parts where light weight and other qualities would be attractive. For other engine stages, a new TiAl alloy that tolerates higher temperatures would have to be developed. Developing and certifying a completely new version would probably require about seven years, in time perhaps for a next-generation GTF.

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Opening

Jim Williams, former manager of the FAA's Unmanned Aircraft Systems Integration Office

The U.S. airspace is poised for a historic transformation with businesses clamoring for the right to fly unmanned aircraft for a variety of purposes, from filmmaking to delivering goods to monitoring natural gas vents. Impatience is running high over the pace of the transformation. Proponents want speedy access to the national airspace, but some pilots warn of potential catastrophe from a sudden influx of additional air traffic. Finding a reasonable path between the two extremes was the job of Jim Williams, who retired in June after a 28-year career at the FAA.

The calm, affable Williams readily lists the progress he says FAA has made, which includes releasing a proposed rule that by next year could let craft of 55 pounds or less legally fly in much of the airspace; unveiling an online application called B4UFLY to teach newcomers how to safely and legally operate their craft; and granting hundreds of exemptions to businesses for the first commercial flights. ***Debra Werner*** *met with Williams at the Small Unmanned Systems Business Exposition in San Francisco to discuss the next steps, including how to accommodate larger aircraft and aircraft that fly beyond the view of their operators.*

Jim Williams says safety is paramount as the FAA moves to incorporate unmanned aircraft into the nation's airspace.

Air Line Pilots Association International

Interview by Debra Werner
werner.debra@gmail.com

the skies to unmanned aircraft

Why is it important to have certified pilots control unmanned aircraft, even small ones?

The FAA Authorization Act requires every aircraft to be operated by a certified pilot. It's the airspace knowledge, the fact that you are operating in the national airspace. Understanding the rules of the road, so to speak. It's like driving a car. You can't take the driving test until you pass the written test.

Are you concerned that some small unmanned aircraft operators don't know where they can and cannot fly?

Yes. Washington, D.C., is the most restrictive area in the country as far as flying model aircraft. We have practically daily occurrences of people flying who are completely ignorant of that fact. We are talking to the National Park Service to try to convince them to put up some signs so people know they are not supposed to fly in the parks.

What would the signs say?

They would just basically say, "It's a no-drone zone. Don't fly your drone here." Something that simple. But the Parks Department is low on money so finding the money to put up signs would be challenging for them.

What about the money you need? Your office has received more than 1,000 requests from companies in filmmaking and other industries for exemptions from the current rules to enable them to fly limited, low-risk operations with small unmanned aircraft. Do you have the staff to handle that?

We actually have reprioritized staff from across the FAA to respond. My office has hired additional help. Congress gave us some money in last year's budget. We are doing pretty well financially. We have approximately 100 people working unmanned aircraft stuff inside the FAA.

What was the level three years ago?

About 25 people when I took over the Unmanned Aircraft Systems Integration Office in 2012.

How has the FAA's view of unmanned aircraft changed since then?

The FAA has recognized the need to make integration of unmanned aircraft into the national airspace a priority. All the way up to the FAA administrator, who has made it one of his priorities.

How are the new [FAA-selected] test sites?

They're coming along. They haven't been operating for a full year yet. They are all different and all have different strategies for achieving their business goals. They all have different funding structures and profiles. There is no federal funding for them.

Are companies going to the sites to test their aircraft?

That was the original congressional intent. Some companies are. A big barrier for small companies is that they don't have a lot of resources for travel expenses, et cetera. So having to travel to the test site locations has been problematic. The test sites in response are starting to open more and more ranges in more and more locations. We are now up to ranges in 12 or 13 different states.

So just because I am working with New York's test site does not mean I have to travel to Griffiss International Airport?

Exactly. The ranges can be all over the place. The UAS Test Sites are the organizations that we work with to facilitate the approvals, it's up to them to decide where they set up shop to operate. For example, the Alaska Test Site has ranges in Alaska, Hawaii, Oregon, Kansas and Tennessee. They have their own safety regime. They come to us with a location and a staff to operate at that location. They are trying to find a way to make it more convenient for companies to take advantage of their services. That was really the intent from Congress in the beginning to facilitate the test and evaluation work for the industry.

When do you think the final small UAS rules will be published?

If it were up to the FAA, it would be a couple months. But it is a long process. It is a priority of the administration all the way up to the White House to get it out. It all depends on the comments and how long it takes us to come up with rationale to resolve them.

When you said at this event last year that it would take seven to 10 years for a major rulemaking initiative like this one, I took that quite literally to mean that it would be several years before this was completed. But it seems to be going much faster.

It originally started back in 2011. That was the initiation date for this rulemaking project. So if we get it done

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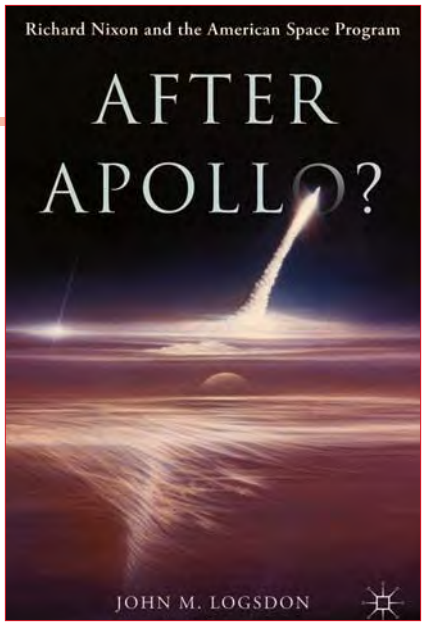
Nixon's shuttle decision — and its consequences

After Apollo?

Richard Nixon and the American Space Program

Reviewed by Edward Goldstein



Palgrave Macmillan

In his third book about presidential decisions on human spaceflight during the Kennedy and Nixon administrations, John M. Logsdon argues that President Richard M. Nixon's space directives — canceling the final Apollo moon landings; forgoing human travel to Mars; postponing serious planning for a space station; and greenlighting the space shuttle program — were more consequential than John F. Kennedy's commitment to the moon landing.

All for the worse.

Nixon's worst call, in Logsdon's view, was his 1972 approval for the now-defunct space shuttles. He argues that decision — made while Vietnam War-weary Americans had scant appetite for new explorations — locked NASA into an expensive, unfocused program while ignoring potentially cheaper and less risky ways to send humans to space.

Nixon did try to wrap himself in the glory of the Apollo astronauts. And he believed NASA should have a soft-power foreign policy role; his pet project was to invite foreign astronauts on future U.S. missions. But his vision for NASA was largely as a domestic agency, one that might even tackle intriguing technology such as desalinization and other Earth-bound problems.

Interestingly, for all the angst about NASA's declining budget, which according to Logsdon then equaled 6 percent of discretionary non-defense federal budget, the agency's budget today is half that ratio.

Logsdon details how Nixon and key budget and political aides came to put their support behind a "full capability" shuttle that could launch into orbit large national security reconnaissance satellites and eventually a large space telescope like the Hubble. They wanted to assert America's space leadership and provide the nation with a new way to launch massive reconnaissance satellites and perhaps capture a satellite owned by a hostile nation (something never attempted). But Nixon also had a political motive; his 1972 reelection hinged in part on winning votes in California, whose aerospace and defense industries were suffering from high unemployment.

NASA

NASA Administrator James Fletcher (left) meets with President Nixon in San Clemente, California, on January 5, 1972, to announce the approval of the space shuttle program.

Logsdon observes, however, that approving the space shuttle came without a meaningful national commitment to post-Apollo space objectives, thus neglecting the long-term purpose the shuttle would serve. He also contends the shuttle never lived up to its promise of being capable of launching people and cargo into space cost effectively, because although NASA accurately projected the shuttle's near-term development costs, it was woefully off base in estimating the system's operational costs. He quotes from the 2003 report of the Columbia Accident Investigation Board, on which he served, as concluding that "the increased complexity of a Shuttle designed to be all things to all people created inherently greater risks than if more realistic technical goals had been set from the start."

Among those goals, Logsdon suggests, may have been to design an X-plane version of the shuttle first and then proceed on an evolutionary basis to a full scale shuttle.

The author concludes that retaining America's leadership in human space exploration will take another president like Kennedy, "once again singling out the space program for special priority and setting challenging goals...and then, crucially, committing on a sustained basis the political, human, and financial resources needed to achieve them."

Logsdon, however, knows the Cold War-era circumstances that enabled Kennedy to shoot for the moon were unique. This is a thought-provoking book for students of space history. It made me think that elected officials should take a hard look at U.S. underinvestment in research and development and consider what NASA can accomplish in the context of an expanded global R&D budget to advance economic growth, technological achievement, exploration and science. And then maybe NASA can get beyond Nixon's legacy and develop a credible technical and budgetary plan and compelling rationale to go to Mars.

Edward Goldstein
edgold18@comcast.net

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in 2016, which more than likely will be the year it comes out, that's five years.

When do you expect the FAA to establish rules for larger unmanned aircraft and unmanned aircraft operating beyond visual line of sight?

That requires the aircraft to be certified. The small UAS rule is the FAA's first step in trying to answer the mail on a lot of very low-risk operations. But it's just the first step. There is way more work that has to be done. You will hear in the near future about what we are going to be doing next. We are moving out in a whole bunch of different areas. It's a long road that will never end to integrate unmanned aircraft into the National Airspace System. There are companies going through the certification process to get their aircraft approved. Once they are approved, some will operate beyond visual line of sight. The big barrier is how do you replace the requirement for the pilot to be able to see and avoid other aircraft. You need some sort of electronic means of compliance. There is a lot of technology out there being developed and examined but no one has actually gone through the certification process to get that approved.

Seven companies are going through that process?

Some are seeking certification to operate within visual line of sight and some would operate beyond visual line of sight. We do already have beyond-visual-line-of-sight operations approved off the coast of Alaska using procedural separation. We've achieved an equivalent level of safety to a pilot's ability to see and avoid based on the fact that when we did a study to determine the aircraft operating density in the area, we couldn't find any. We had no historical record of an aircraft operating in that area below 2,000 feet. That's not to say that there won't be in the future. So we set up a process to coordinate. If a manned aircraft is going to go there, there's a coordination process to say, "Are there any unmanned aircraft operations?" If no, no problem. If yes, we need to coordinate getting the unmanned aircraft on the ground so the manned aircraft can fly. We give right-of-way to the manned aircraft operations.

Jim Williams

Title: *Retired June 1 as manager, FAA Unmanned Aircraft Systems Integration Office since March 2012*

Age: *55*

Birthplace: *Maryville, Tennessee*

Education: *Bachelor's in aerospace engineering, Georgia Tech*

Previous positions: *Director of FAA's Office of Systems Engineering and Safety (2005-2012); safety management director and integration director for FAA's Air Traffic Organization (2004-2005); various other FAA management positions since 1987; flight test engineer at Lockheed-Georgia Co. (1985-1987); space shuttle mission controller, NASA Johnson Space Center (1981-1985).*

Residence: *Reston, Virginia*

Notable quote: *"We are moving ahead as fast as we can while maintaining the safety of the national airspace."*

Are there also government agencies that operate unmanned aircraft beyond the visual line of sight of the operator?

The Customs and Border Patrol fly their aircraft on both borders in controlled airspace as we speak. They have 10 aircraft split between the two borders. They have special maritime aircraft that patrol the Gulf of Mexico and off the coast of California. They all operate in contact with air traffic control intermixing with manned aviation. That's been happening for a while.

Can unmanned aircraft help fight fires?

There is a lot of potential there but there are also a lot of risks because firefighting with aircraft is very dangerous. Intermixing unmanned aircraft into firefighting has to be done carefully so it does not increase the risk of an already risky operation. They are taking it slow and steady.

Is it complicated because air tankers and scouting planes are already flying?

Yes. And there's smoke and you get these tremendous hurricane-force winds that are created as the air rises and mixes with the air currents. It's a very dangerous environment for manned aviation.

How many exemptions have you granted companies under Section 333 of the FAA Modernization and Reform Act of 2012 to allow them to operate unmanned aircraft to perform limited, low-risk operations without getting airworthiness certification for the aircraft?

Two hundred forty-six as of April 29. We are starting to crank them out now. It can change daily.

How does the FAA enforce unmanned aircraft rules?

The FAA is not about enforcement but about compliance. We can't be everywhere. We only want to get involved in identifying the really bad actors. We communicate with people who disregard the rules. We have a standard letter we send. Enforcement is a last resort. The only rules people need to know is to stay out of the way of manned aircraft and not to put people on the ground at risk. It's that simple. But unfortunately people don't even know that. New York City police arrested two guys who chased after one of their police helicopters.

What are your plans for retirement?

I'm looking for a job in the Unmanned Aerial Systems industry where I can make a significant contribution to civil use of Unmanned Aerial Systems.

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Award accepted by
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Wilde Lake High School
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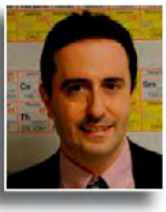

Gary Garber
Instructor of Physics
Boston University Academy
Boston, Massachusetts

Heather L. Stewart
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Ring Chair & Professor, Mechanical Engineering Department
University of Memphis
Memphis, Tennessee

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Retired President and CEO, The Ford Motor Company
Board of Directors, Google

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Michael Sinnett, Vice President, Product Development and the Boeing 787-8 Development Team

Thank You, Nominators!

AIAA appreciates your time and effort in preparing the nomination package!

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Martiqua Post
Rosemary White
Robert Walter

To view awards open for nomination, visit http://www.aiaa.org/HonorsAndAwardsOpenNominations.aspx?id=5858

Five aerospace teams are vying for up to $14 billion in NASA contracts to dramatically boost the amount of cargo delivered to and from the International Space Station. The competition pits industry stalwarts against relative newcomers, and traditional mission designs against daring innovation. Debra Werner looks at NASA's options and the potential payoffs to astronauts.

UPPING the station's upmass

The stakes for NASA's latest competition to deliver supplies to the International Space Station were laid bare in April, when a Russian Progress cargo ship spun out of control toward the end of its ride to space on a Soyuz rocket. More than 2,700 kilograms of cargo burned up in the atmosphere over the Pacific Ocean, forcing the six person crew to go without fresh produce until the next resupply flight, a SpaceX Dragon scheduled at press time to launch June 26, 2015. The failure came just six months after an American-built Cygnus cargo capsule was destroyed when its Antares launch vehicle exploded during liftoff from Wallops Island, Virginia.

Even when all goes right, the station crew must rely on a dwindling fleet of freighters. Europe's Automated Transfer Vehicle stopped flying in 2014; Japan's H-2 Transfer Vehicle is scheduled to deliver cargo once a year until it retires in 2019, and the space shuttle fleet flew its last mission in 2011. Nearly all supplies are delivered by Russian-government Progress ships, plus two kinds of commercial vehicles that NASA added to the mix after a 2008 competition: The SpaceX Dragon and Orbital ATK Cygnus capsules.

NASA wants to solve the dearth of delivery options by increasing the mass that can be delivered to the station, and it is in the closing weeks of a high-stakes indus-

by Debra Werner
werner.debra@gmail.com

The competitors

Five companies are chasing the next cargo contract for the International Space Station

SpaceX Dragon

Observers say SpaceX is well positioned because of the seven Dragon missions flown to the station so far, including a demonstration mission. The existing Dragon includes a 14-cubic meter trunk that is jettisoned to dispose of trash in the atmosphere while the main capsule returns cargo to Earth. Here are more details of the current version:

Dimensions:
7.2 meters long, 3.7-meters diameter, including a disposable trunk

Maximum load:
3,310 kilograms up; 2,500 kilograms down plus 810 kilograms burned up in disposable trunk

Launch vehicle:
Falcon 9

Landing:
Ocean splashdown

Reusable?
Not yet, but SpaceX aspires to that

Boeing Crew Space Transportation-100 (CST-100)

Boeing argues NASA would save money by adding cargo to the CST-100's mission of carrying astronauts to the space station. Boeing hasn't spelled out the adjustments it would make for a cargo version, but it will on reentry land under parachutes at one of five sites in the U.S.

Dimensions:
5 meters long, 4.6-meter diameter

Maximum load:
Boeing won't comment, except to say CST-100 cargo version will carry at least 2,500 kilograms

Launch vehicle:
Atlas 5

Landing:
Touches down on land

Reusable?
Yes

Orbital ATK Enhanced Cygnus

After three flights to the station, Cygnus was sidelined last October when an Antares rocket exploded in a launch attempt from Virginia. While the company works on the Antares, it will get back to business in November by using an Atlas 5 to launch a new, larger version of Cygnus with updated electronics. Orbital ATK hasn't provided details of its bid for the new cargo contract, but here are details for Enhanced Cygnus:

Dimensions:
4.9 meters long, 3-meter diameter

Maximum load:
3,500 kilograms to and from space station

Launch vehicle:
Orbital ATK Antares; Atlas 5

Landing:
None, burns up on reentry

Sierra Nevada Dream Chaser

This is the only non-capsule design in the competition. The cargo version would ride to space shrouded by a rocket fairing, and after the mission its wings would deploy mechanically for a runway landing. Sierra Nevada says the exact deployment method is competition sensitive.

Dimensions:
10 meters long, 8-meter wingspan

Maximum load:
5,500 kilograms up; 1,750 kilograms down. Also can release 3,250 kilograms to burn up in the atmosphere.

Launch vehicle:
Atlas 5 or Europe's Ariane 5

Landing:
8,000-foot conventional runway

Reusable?
Yes

Lockheed Martin Jupiter and Exoliner

This is the only entirely new concept in the competition, although Lockheed Martin says it will rely on technologies proven on other missions. An orbiting Jupiter space tug would deliver disposable Exoliner containers to the station using a robotic arm.

Dimensions:
9.7 meters long, 4.4-meter diameter

Maximum load:
5,000 kilograms in a pressurized compartment; 1,500 kilograms in an unpressurized compartment

Launch vehicle:
Atlas 5

Landing:
None, used Exoliners burn up in the atmosphere; Jupiter remains in orbit

Source:
Aerospace America research

try competition for the right to do that. Dragon and Cygnus have carried 14,000 kilograms of cargo in six flights over the span of three years under the original 2008 contracts. Starting in 2018, NASA wants to send about that amount in a single year and possibly much more by upping the annual launch tempo to four to five flights. This desired annual upmass of 12,000 to 32,500 kilograms has made the Commercial Resupply Services-2 competition a coveted $14 billion prize that's likely to be split among multiple winners.

There could be added benefits to boosting the upmass.

"Launching more and more often over time should reduce costs and increase reliability since, as with anything in human experience, you will get more efficient and proficient over time," says Frank Slazer, Aerospace Industries Association vice president for space systems.

Vying for the CRS-2 contracts are two incumbents, SpaceX and Orbital ATK; Sierra Nevada Corp. with its winged lifting body Dream Chaser; Boeing with a modified version of its CST-100 capsule; and Lockheed Martin with Jupiter, a refuelable space tug that would stay in orbit for at least 12 years to grab newly launched cargo modules with its robotic arm, take on fuel for its hydrazine engines and ferry expendable cargo containers called Exoliners to the station.

NASA plans to announce the winner or winners in September, and as is typical in the closing weeks of a multibillion competition, the agency isn't saying much. Outside of NASA, there is plenty of discussion about the future cargo delivery contracts. Much of it centers on how many companies NASA will select — the agency won't say — and whether anyone can beat SpaceX, the pioneering leader of the "new space" startups that are happy to serve government customers, provided they get to do most things their way.

Last year, NASA chose proposed passenger versions of the SpaceX Dragon and the Boeing CST-100 to deliver astronauts to the space station under a separate Commercial Crew Services program, turning aside Dream Chaser, one of the current competitors.

"Most people assume SpaceX is a shoe-in," says Charles Miller, president of NextGen Space LLC, a space and public policy consulting firm in Arlington, Virginia. If that conventional wisdom proves correct, the remaining question becomes who else NASA might pick.

Why does SpaceX appear to have an edge? Not only is the company's Falcon 9 rocket far less expensive than its competitors, the company has more experience than anyone else delivering space station cargo, says Marco Cáceres, senior space analyst at Teal Group in Fairfax, Virginia. In the six commercial flights performed through May of this year, the SpaceX Dragon carried about 10,000 kilograms to the station (about the weight of a school bus) and brought back another 8,000 kilograms, according to NASA cargo manifests and press releases.

"If NASA's goal is to find a company that can transport cargo to station as reliably and cheaply as possible, SpaceX will be hard to beat," Cáceres says.

Daring architecture

If SpaceX leads on price and experience, Lockheed Martin hopes to win with innovation. It wants to sell NASA on the idea of using Jupiter to ferry Exoliners to the station. Each Exoliner would carry 5,000 kilograms in a pressurized compartment and 1,500 kilograms in an unpressurized compartment.

On the first mission, Jupiter and an Exoliner would be stacked inside the shroud of a United Launch Alliance Atlas 5. After release, Jupiter would fire, turn on hydrazine engines to whisk the container toward the space station, where the station would use its robotic arm to pull it to the airlock. Astronauts would unload supplies sent by NASA and fill Exoliner's pressurized and unpressurized compartments with waste materials, small satellites and science experiments. Jupiter would then maneuver the Exoliner to an elliptical or "racetrack" orbit that is slightly above or below the space station to keep Jupiter and Exoliner safely out of the station's path, but still close enough for cargo deliveries.

With Jupiter safely in orbit, Lockheed Martin would launch Exoliners on successive Atlas 5s, using the rocket's Centaur upper stage to rendezvous with Jupiter at an intermediate orbit well below the space station's. Lockheed Martin hasn't said exactly how Jupiter's robotic arm would ex-

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>
> **Marco Cáceres**
> Senior Space Analyst at Teal Group

change the old Exoliner and refueling modules for the new ones, except to say that the old Exoliner and refueling module never orbit freely. They would be placed on the Centaur, which would carry them back into the atmosphere to burn up. Jupiter would then tug the new Exoliner to the space station for another delivery. Lockheed Martin flight controllers would monitor the mission from the ground.

Lockheed Martin knows that this approach would be a new way of delivering supplies to the station. The company is trying to counter concerns about the additional rendezvous step by pointing to the spaceflight heritage of its components. Lockheed Martin engineers patterned Jupiter after their design for the Mars Atmosphere and Evolution probe that arrived in orbit around Mars last year. Lockheed Martin's partner, Italy's Thales Alenia Space, plans to model Exoliner on the pressurized cargo module the firm built for the Automated Transfer Vehicles that carried supplies to station from 2008 to 2014. Even the robotic arm looks familiar. Designed by Canada's MDA Corp., it will be modeled on robotic arms MDA supplied to the space shuttle and space station programs for 30 years, says Lockheed Martin's Tim Priser, the company's CRS-2 proposal manager.

Lockheed Martin refers to Jupiter and the Exoliners as multipurpose space vehicles, because in addition to delivering cargo to the station, they could in theory rendezvous with other satellites or carry cargo beyond low Earth orbit. Lockheed Martin has even suggested to NASA that it put a stationary bike or other exercise equipment in the pressurized section of an Exoliner and dock it to an Orion crew vehicle, which Lockheed Martin is also developing, so the astronauts could carry additional life-support equipment and get exercise during a long mission to deep space.

"Instead of just a simple FedEx machine that delivers cargo for station, this is something that looks like a habitat," Priser says.

Chasing the dream

Lockheed Martin isn't the only company arguing that its proposal has value beyond the station. Sierra Nevada says that its winged Dream Chaser Cargo System, the only contender that would land on runway, could be modified for Earth observation or scientific flights, to retrieve and repair satellites or to nudge the space station a little higher in orbit when necessary. Observers were surprised last year when NASA did not pick Dream Chaser as one of the commercial craft to carry astronauts to the station, given its resemblance to a space shuttle orbiter. The agency instead chose Boeing's CST-100 and SpaceX's Dragon capsules. Sierra Nevada hasn't given up on carrying astronauts and suggests that the cargo craft could be adapted for that purpose, too.

Sierra Nevada continues to work on the crew version of Dream Chaser with its own money and some from NASA. Over the last nine years, it has received $363.1 million from NASA. Regardless of how the cargo competition turns out, the firm plans to conduct a flight test of its original Dream Chaser design from California's Edwards Air Force Base by the end of the year.

Unlike the piloted version, the Dream Chaser Cargo System would fly to space and land on a runway autonomously. Its wings would deploy mechanically before the trip home. The crew version would have flown atop Atlas 5s without a shroud and with its wings deployed. In orbit, large solar arrays would provide power. Sierra Nevada would equip the Dream Chaser with an expendable cargo module designed to be ejected to burn up in the atmosphere with up to 3,250 kilograms of trash. In all, Dream Chaser could transport 5,500 kilograms to the station and bring 1,750 kilograms back to Earth for a runway landing.

Despite the crew competition setback, Sierra Nevada casts the runway landing as a key selling point. Dream Chaser would need no more than an 8,000-foot runway, typical of regional airports. It uses nontoxic propellants, which means a ground crew could unload cargo quickly.

"You need to get those experiments back in the hands of the researchers as soon as possible or the quality of the science starts to degrade," says Steve Lindsey, a veteran of five space shuttle missions who now runs Sierra Nevada's Space Exploration Systems unit.

Expanded mission

Boeing hopes to sell NASA on the idea of buying CST-100 cargo flights on top of the work it's already doing on the crew version for NASA, which it says would lead to economies of scale and lower the vehicle's overall cost. At the end of a mission, onboard guidance, navigation and control software would calculate precisely when the spacecraft would need to begin its reentry to reach one of five U.S. landing sites. Thrusters would reduce its speed to start the process, and high in the atmosphere the blunt-cone capsule would reorient itself and use atmospheric drag to reduce its velocity. High-speed drogue parachutes would deploy, followed by three main Kevlar and nylon parachutes. The main chutes open in stages to gradually slow the capsule until it nears the ground and releases six airbags to reduce the force of impacts.

Boeing engineers designed CST-100 with astronauts in mind, and they made sure crews could climb on board shortly before takeoff and exit quickly when the capsule reached its destination. NASA could take advantage of that same design to move cargo quickly onto and off the spacecraft, Boeing says.

Quiet incumbents

SpaceX officials declined to discuss any plans to modify Dragon for NASA's CRS-2 competition, but observers don't expect the company to make significant changes to the current design or operations.

Dragons are launched on Falcon 9 rockets from Cape Canaveral. Outside the atmosphere, the Dragon jettisons a nose cap that covers the vehicle's space station docking hatch. Beneath the hatch, Dragon has an 11-cubic-meter pressurized cargo bay and a 14-cubic-meter unpressurized cargo hold known as Dragon's Trunk. When the spacecraft leaves the space station, the Trunk separates from the primary capsule and burns up on reentry, while the main capsule reenters and slows for landing with the help of two drogue parachutes and three main parachutes.

The existing Dragons can deliver and pick up a maximum of 3,310 kilograms of cargo. On the return trip, Dragon can bring home a maximum of 2,500 kilograms and dispose of the rest in Dragon's Trunk, according to the Commercial Resupply Services contract NASA awarded SpaceX in 2008.

Orbital ATK officials also declined to discuss their CRS-2 proposal but agreed to talk about Cygnus's ongoing space station delivery work. The cylindrical Cygnus spacecraft conducted three NASA cargo missions between September 2013 and July 2014, before the rocket failure in October 2014.

During its first three missions, Orbital ATK delivered 3,629 kilograms to the space station, about the weight of two F-150 pickup trucks. Orbital ATK does not bring cargo back to Earth. Instead, astronauts pack the capsule with the space station's trash, which burns up in the atmosphere. "We've taken away more cargo than we've delivered, which is a very valuable service to NASA," says Frank DeMauro, Orbital ATK vice president of human spaceflight systems.

He emphasizes this experience as an incumbent: "We have a very competitive and compelling offering based on what we've already shown is a very successful system."

Orbital ATK is in the process of upgrading Cygnus for five additional cargo missions it plans to perform for NASA under the original Commercial Resupply Services contract. Beginning in November, Orbital ATK will carry NASA cargo in the Enhanced Cygnus, which includes new radios and navigation sensors, improved solar arrays and a cargo module built by Italy's Thales Alenia Space to hold 3,500 kilograms compared with 2,300 kilograms for the initial Cygnus model. The November flight will be on an Atlas 5 from Cape Canaveral. Orbital ATK plans to purchase one or two Atlas flights while the company upgrades Antares and replaces its first-stage AJ26 engines due to concerns that their failure may have caused the October accident.

Much of Orbital ATK work focuses on integrating the spacecraft's hardware and software, but DeMauro keeps reminding his team that their ultimate goal is supplying astronauts. "The first chart I show in every all-hands meeting is a picture of the crew to remind everyone that those are the folks we are really working for," DeMauro says. "Our management is counting on us to succeed and NASA is counting on us to succeed, but no group of people are counting on us more than those crew members."

Predict trouble/

The decades-old trend of attaching sensors to components on airliners to gather performance statistics and receive failure alerts is expanding to more components and new kinds of predictive maintenance services. Computer and aviation experts attribute these developments to the newest big-data analytics software that can do in a flash what used to take minutes or longer, the proliferation of applications for smartphones and tablets and to the advent of broadband satellite communications between aircraft and the ground.

Engine makers led the way to predictive maintenance more than 30 years ago by collecting performance readings from aircraft during flight and studying it for trends. The technique is spreading well beyond engines, and includes real-time downloading of defect data, for example, via the Airbus Real Time Health Monitoring service, which monitors the performance of components on A380 and A350 XWB extra wide body jets in flight. Later this year, AiRTHM expertise will be available to airlines on mobile devices.

As powerful as AiRTHM is, it reflects an early form of real-time monitoring, because it is limited to receiving short messages downloaded via ACARS, the satellite-based Aircraft Communications Addressing and Reporting System. Today, the cost of broadband satellite links means that the bulk of the peformance data is downloaded after the plane lands, and software then compares this data to the statistical records for specific parts in search of

by Henry Canaday
htcanaday@aol.com

Airbus

Avoid trouble

Airliners are amazingly safe but expensive to maintain. One way to put a dent in those costs would be to know in advance which parts are likely to require maintenance and when. Henry Canaday examines the predictive analytics revolution unfolding in the airline industry.

Qatar Airways was first to fly the A350 XWB, one of two Airbus models served by AiRTHM, Airbus' real-time maintenance troubleshooting program.

symptoms that preceded other failures.

That is changing though. As broadband links become more affordable and airlines choose to make predictive maintenance an even higher priority, experts expect more data to be downloaded to data centers in real-time so it can be parsed using the newest big-data analytics techniques. Airlines stand to gain economically and customers stand to gain from fewer flight delays. In rare cases, safety might even be at stake when an impending fault is discovered.

If an "aircraft is about to fly over [the] Pacific Ocean, one may decide to come back to [the] airport without taking the risk," says Sam Adhikari of the big data analytics firm Sysoft in Whitehouse Station, New Jersey.

The newest computers and software promise to race through big data sets in seconds using a technique called in-memory computation, in which computations are done in the same area of the computer where the data is stored. Adhikari says he expects widespread adoption of this technology in three to five years, so that predictive maintenance analysis can be done while a plane is in flight.

HOW IT ALL BEGAN

Airbus began health monitoring in the early 1990s with software called AIRMAN, short for Aircraft Maintenance Analysis. AIRMAN offered basic defect alerts on a limited number of components. The airline itself had to arrange the transmission of these alerts via ACARS, then interpret them and act upon them.

> ***"We want to use the history of interruptions, maintenance system records, real configurations and all possible data related to failures to develop better predictive models."***
>
> **Philippe Gourdon, Airbus**

In a shift away from this do-it-yourself approach, Airbus added a more ambitious service in the early 2000s during development of the A380. This was AiRTHM, a service that Airbus provides for airlines that fly A380s and now also Qatar Airways, the first airline to fly the A350 XWB extra-wide-body.

The AiRTHM process begins with AIRMAN onboard software monitoring seven key systems: fuel, engine, oxygen, pneumatic, hydraulic, air-conditioning, and landing gear. This time, if a defect occurs in flight, information is transmitted to Airbus ground staff instead of to the airline. If the defect is judged critical, meaning it could affect the aircraft's next flight, Airbus staff interrogate the plane via ACARS and seek information from other components to try to identify the root cause. They troubleshoot the problem before the aircraft lands and immediately contact airline maintenance managers on ordinary ground communications, advising them on how to rectify defects as quickly as possible when the plane lands.

The goal is to simplify predictive-maintenance by making the manufacturer responsible for the main critical monitoring elements: sensors, data transmission and analysis. The airline has only to receive and act upon AiRTHM guidance.

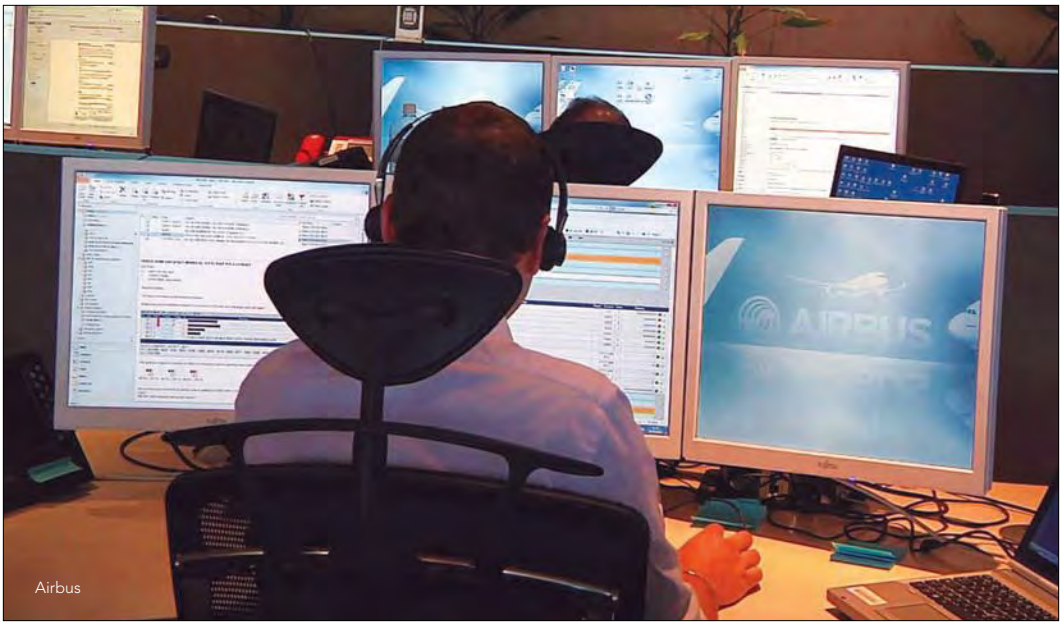
AiRTHM also has a longer-term aspect. Airbus staff monitor performance trends by recording data during flight and downloading this data on landing. The aim here is to predict future failures and enable their prevention by timely action. Airbus staff advise maintenance planners at the airlines about likely future problems.

Airbus expects the service to be most popular among young or lean airlines. Major carriers still prefer to control predictive maintenance, so Airbus is inserting the expertise of AiRTHM into a new version of AIRMAN for direct use by airlines.

AIRMAN software installed in airline maintenance-management offices will soon have an Expert module, which is software that contains all the expertise that Airbus staff have been using to provide the AiRTHM service. Carriers will get notices of inflight defects directly and immediately via ACARS, rather than having the information routed through Airbus. AIRMAN's forthcoming Expert module should enable airline staff to distinguish between critical and non-critical defects, and guide them through troubleshooting steps, including the right interrogatories to send the aircraft while in flight via ACARS.

The Expert module's knowledge base will be essential, explains Philippe Gourdon, vice president for

Airbus Real Time Health Monitoring provides predictive maintenance and real-time troubleshooting services for the A380 and the A350 XWB. Airbus can remotely access data from the aircraft via the satellite-based Aircraft Communications Addressing and Reporting System.



Airbus

business information management at Airbus. Defects can have many root causes. Finding the right one efficiently requires understanding of the aircraft's architecture. The new approach puts an application on airline PCs and mobile devices to exploit all of Airbus' troubleshooting wisdom to find root causes of defects. "They will have an app that makes that simple, that hides the complexity," Gourdon summarizes. AIRMAN Expert modules will be available in late 2015 on A330 and A380 widebodies and early in 2016 on A320s and A350s, Airbus says.

AiRTHM's trend monitoring capabilities will be given directly to users in a second new AIRMAN application, Prognostics and Risk Management. This will give airlines the benefit of AiRTHM techniques in identifying possible failures early.

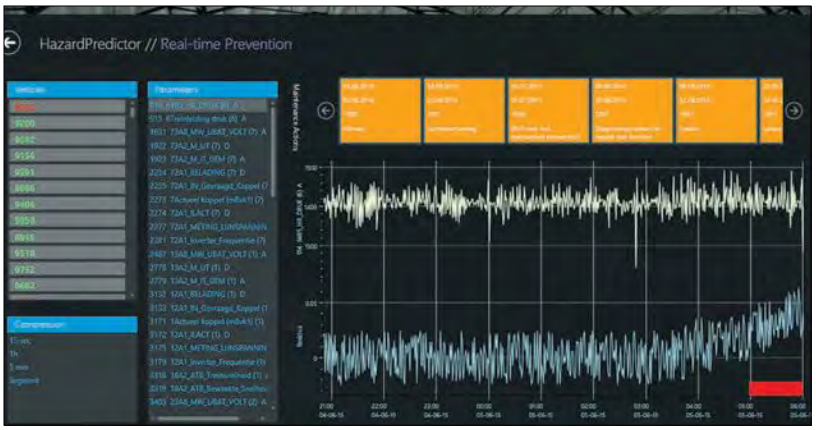
One example is a release valve in the bleed-air system, the system that takes air from engine compressors to maintain pressure in air-conditioning, anti-ice, hydraulic and many other systems. Airbus has found that if this valve starts to close more slowly, this can foreshadow future failure.

By spotting slow closure early, an airline can either replace the valve promptly or reassign the aircraft to another route that requires less work from the bleed-air system. Airbus is testing Prognostics and Risk Management with two carriers and will release it in late 2015 for A330s and 380s and next year for other models.

Apart from allowing airlines to exploit AIRMAN capabilities and AiRTHM expertise in-house, Airbus also wants to make its predictive capabilities more powerful. It is working with easyJet and formed a partnership with IBM in 2013 to bring a global IT leader into this effort. "We want to use the history of interruptions, maintenance system records, real configurations and all possible data related to failures to develop better predictive models," Gourdon explains.

EXPLOITING STATISTICS

Most predictive techniques start out as physical models based on how aircraft components are supposed to work according to the engineers who designed the components. But as experience is gained and sensor data accumulates, a statistical or big data approach can be applied to provide a much richer understanding of potential problems.



Top: Frankfurt Consulting Engineers's Dashboard for predictive maintenance for bleed-air and air-conditioning systems shows location of all aircraft on a map, and tracks their arrival airports and whether the systems are healthy, indicated by green, or headed for potential failure, in red. **Bottom:** The left column on the screen shows hydraulic pressures, electrical measures and other indicators for the air-conditioning and bleed systems. The right column shows the air-conditioning system's air mass flow from left engine (top) and its deviation from normal operation (bottom).

The statisticians at Frankfurt Consulting Engineers in Germany, a company that specializes in algorithms and probability theory, have been using their Anomaly Detection Software since 2004, mostly in the power and rail industries. Four years ago, they got a call from Finnair Technical Services, the maintenance arm of Finnair, which was having problems with its bleed-air and air-conditioning systems.

Anomaly detection is pure math, or at least starts that way. Frankfurt takes the historical data from a system's sensors and builds an empirical model of how the system behaves when it is healthy. This is an abstract model, composed entirely of equations. The equations forecast how the healthy system should evolve over time and Frankfurt staff compares this forecast with actual sensor data.

The software can often spot potential problems early. When double-checked against data on actual failures, it becomes even more accurate. Frankfurt considers it a supplement to AIRMAN, AiRTHM and other manufacturer-based predictive tools.

> ***"Our airline customers told us not to tie their hands on how they use the data..."***
>
> **Todd Young, Bombardier**

The approach is now being used as well by Zurich-based SR Technics, a maintenance firm with eight logistics centers in Europe, Asia, the Middle East, Australia, with stations at 16 airports. The software has been expanded to systems "in every corner of the aircraft," says to Sebastian Feller, project leader for condition monitoring at Frankfurt.

Temperatures, air flows and pressures at different points are the major parameters monitored in the bleed and air-conditioning pipes. For brakes and wheels, data is sought on temperatures, actuation pressures and speed. For auxiliary power units, Anomaly Detection works with air flows, pressures and temperatures. For hydraulics and landing gear, pressure is among the critical parameters necessary to detect a gradual wearing out.

Frankfurt is even attempting to obtain early warnings for the electronic systems that, on airplanes as in homes, usually fail suddenly without warning. Feller says aircraft electronics often have hidden redundancies. By spotting the unnoticed failures of these redundancies, engineers can spot a component that is much more vulnerable to imminent failure.

Frankfurt's anomaly detection currently works on the ground with sensor data downloaded after each flight. That is fine for problems that take days or weeks to develop. But some failures happen faster.

So SR Technics and Frankfurt are now testing another approach. A subset of detection algorithms is being installed on a customer's A320. If the software detects an immediate problem, a notice and 10 seconds of relevant sensor data will be sent to the ground via ACARS for more complete analysis by all the detection equations.

The Frankfurt statisticians are also trying to improve their algorithms. They want to tell maintenance managers not only that there could be a problem in a component, but predict the specific failure mode and forecast its most likely timing in flight hours. For these purposes they will be combining their sensor data and statistical models with databases compiled by engineers and maintenance technicians.

EXTENDING BENEFITS

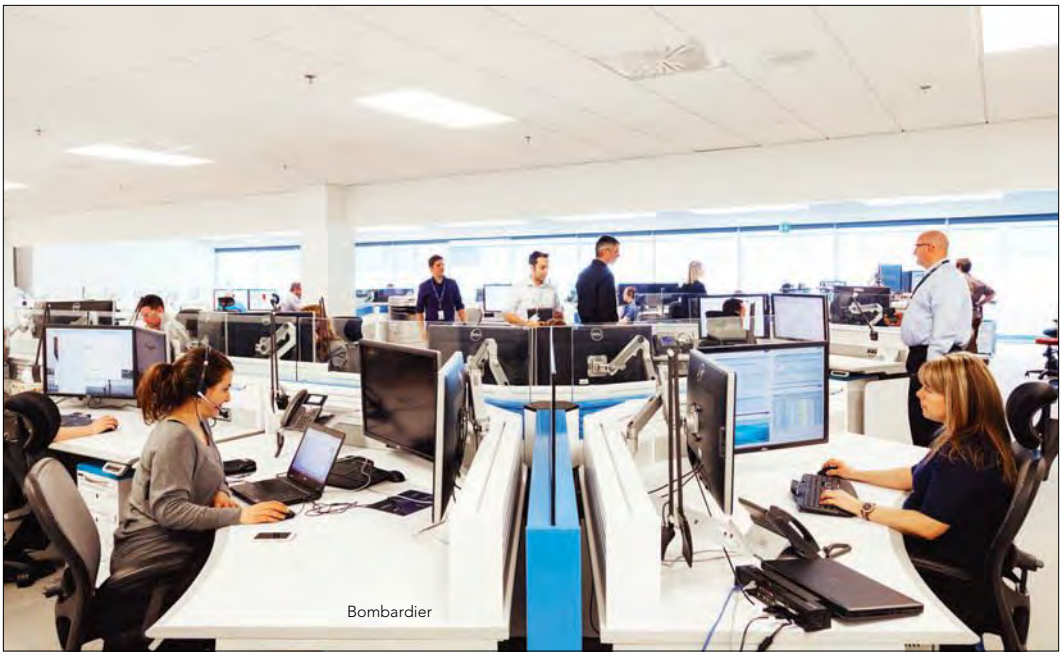
Predictive maintenance has extended well beyond Airbus. Bombardier's Aircraft Health Management System on its new C Series regional jets, now in test flights, tracks, monitors and records 5,000 parameters from major systems. These include avionics, flight controls, fly-by-wire, landing gear, braking, environmental control, thrust reversers, engines, electrical systems and auxiliary power units.

The Bombardier software can trigger automatic alerts on defects, transmitted to the ground via ACARS, to initiate maintenance. It can also store data on up to 100 flights. But the system will usually download each flight's data on landing.

Bombardier also offers a service in which Pratt & Whitney collects and processes this downloaded data and Bombardier uses it to provide prognostics to the airline. Or an airline can arrange for download, processing and interpretation itself. "Our airline customers told us not to tie their hands on how they use the data," explains Bombardier's Todd Young, vice president for customer service.

Predictive maintenance may become even more widespread, if UTC Aerospace Systems has its way. The company's Sensors & Integrated Systems unit has developed what it calls Health and Usage Monitoring Systems or HUMS for a wide range of helicopters flown by the military and the oil and gas industry. It is now seeking to apply HUMS to fixed-wing aircraft.

HUMS Program Manager Kevin Hawko says the system has helped reduce maintenance man-hours, unplanned maintenance and mission aborts by double-digit percentages in military rotorcraft. It could be applied to large or smaller commercial aircraft or business aircraft. HUMS is best suited to help maintain auxiliary power units, fans, power generation and distribution systems and landing gear. It uses algorithms to diagnose vibrations and other performance parameters, estimating the



Troubleshooting: Staff at Bombardier's customer response center in Mirabel, Quebec, tap its Aircraft Health Management System for data to solve customer problems.

remaining useful life of aircraft systems and components.

Hawko says HUMS could supplement predictive systems already installed on big jets or give less sophisticated aircraft a powerful new capability. He urges operators to identify the unplanned maintenance events that cost the most in diversions, delays and cancellations. Then UTAS can tailor HUMS to reduce these losses.

BETTER DOWNLINKS

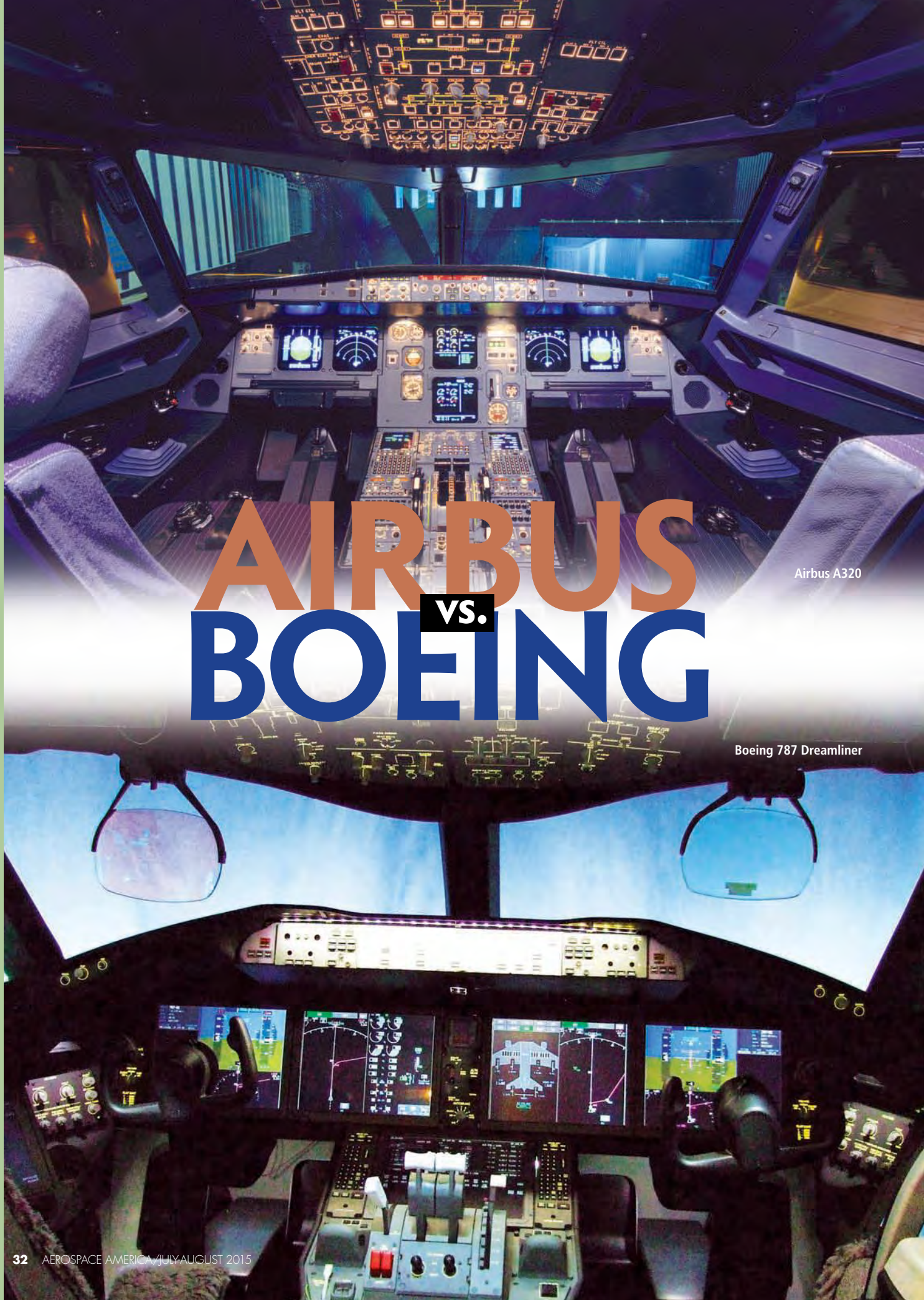
The narrow ACARS communications pipeline between aircraft and the ground has so far limited the depth of real-time monitoring, but faster communications are now in view. Satellite communication is making possible broadband Internet-protocol links that are much more efficient than ACARS when lots of data is needed. These links are already being used for some passenger amenities like email and web-surfing. Older aircraft do not collect sufficient data to justify rapid downloads via broadband links, but these aircraft are gradually being replaced in fleets.

There are hurdles to adoption. It is difficult to obtain licenses for data downloads over some countries, but negotiations are addressing that problem. Then there are costs, both variable costs for downloading data and fixed costs for installing communication equipment. Transmission cost is high now, but this cost is declining. Moreover, an airline does not need to download all the 500 gigabytes a Boeing 787 generates in one flight.

Fixed cost for communication equipment can be spread over several systems, for maintenance, aircraft management and passenger entertainment. This raises the security flag: However operating data is transmitted and received, it must be done at a very secure level, unlike less-critical passenger data. Representatives from the airlines, satellite and IT firms are working on this challenge as a group called the SC-216 Aeronautical Communications Security Panel, organized by the not-for-profit RTCA association, founded in 1935 as the Radio Technical Commission for Aeronautics.

Meanwhile, satellite firms are preparing for better communication. By the end of the year, London-based Inmarsat expects its new Global Xpress geosynchronous satellite network to handle 50 megabits per second for users around the world. The GX network is primarily designed to handle passenger communication. But by 2016, Inmarsat expects to offer a slower service, SB Safety, for safety-related transmissions such as data for predictive maintenance.

Boeing, which has long been eager for better inflight connections for its health monitoring systems, is equipping 777s, 747-8s and 787s to download over more efficient satellite networks.



AIRBUS VS. BOEING

Airbus A320

Boeing 787 Dreamliner

VIEWPOINT

by CLINT R. BALOG
BALOGC@erau.edu

Whose automation philosophy is best?

Airbus and Boeing each use automation to make flying safer and easier. But the world's two dominant manufacturers of large passenger jets have very different philosophies about how computers and pilots should interact. Clint R. "Clutch" Balog, a professor of aeronautics, ventures an opinion about which approach is best.

THERE IS NO DOUBT that automation has advanced aviation safety by leaps and bounds. It remains, however, a double-edged sword, bringing with it such problems as degradation of basic flying skills, loss of situational awareness, and an increase in pilot complacency and automation dependency.

Boeing and Airbus each embrace automation, but their philosophies differ regarding how best to apply it. Both companies say their designs give ultimate control of the aircraft to the pilots. Yet fundamentally, Airbus' philosophy is automation-centric while Boeing's is human-centric. Airbus focuses more on avoiding pilot error than on taking advantage of human capabilities. It does so from the outside in by allowing automation to at times override the pilot and his or her decision making. This can be seen in Airbus' publicly available philosophy statement, which says that "all aircraft have physical limits that they must not exceed" and that such flight-envelope limits "are not to be exceeded during normal operations."

Boeing, in contrast, focuses more on taking advantage of human performance — or the pilots' collective physiological and psychological performance capabilities — rather than avoiding human error. Boeing does so from the inside out by using automation to aid the pilot in his or her decision making. Automation, according to Boeing, is "to assist, but not replace, the flight crew member responsible for safe operation of the airplane."

In short, Boeing guides the pilot; Airbus limits the pilot.

Answering the question of which philosophy is better can be as complex as the software code that drives the industry's state-of-the-art automation. But in my view, Boeing has developed the better approach. As a cognitive research psychologist and chair of the Master of Science in Human Factors program at Embry-Riddle — Worldwide, I conduct research on human cognition, performance and error. This involves extensive interviews with pilots regarding how they function in highly automated cockpits, particularly during in-flight emergencies. And as a former engineering test pilot and a contract corporate pilot, I still fly some highly automated aircraft.

But first, let me note some basic operational similarities between Airbus' and Boeing's automation implementation. Pilots aboard both aircraft can generally disengage the autopilot and autothrottles simply by using disconnect buttons. This gives manual control of the flight controls and throttles back to the pilot. But the pilot of a

Airbus

The Airbus A320 is equipped with a glass cockpit and digital fly-by-wire flight controls. Two pilots use side sticks that move independently of each other, with the inputs relayed only to the flight control computers.

Boeing aircraft can also disengage the autopilot by applying sufficient force to the center control yoke. This can be an advantage — in the event of a sudden traffic conflict avoidance maneuver, for instance. Yet in an Airbus aircraft, a push on the side stick controller, no matter the force or rate, will not disconnect the autopilot.

The autopilot is only a portion of the automation story. It is in the flight control computers that the philosophical difference between the two manufacturers is most noticeable operationally. Both manufacturers provide flight envelope protection by way of software-defined limitations in the FCCs. The difference between the two, though, is that Airbus defines hard flight envelope limits, beyond which the pilot cannot go regardless of circumstance. Only some pitch and roll limitations, but not load-factor limitations, are shed during a dual FCC failure in "alternate law" mode. More, but still not all, limitations are shed if all three FCCs fail, termed "direct law" mode.

By contrast, Boeing sets soft limits that pilots can go beyond if they deem it necessary. This would typically occur during abnormal and emergency operations, but it is available during normal operations as well. And unlike the autopilots and autothrottles, the FCCs in either Boeing or Airbus aircraft cannot be disconnected by a pilot in a normal operational manner. This means in the Airbus design some flight envelope limitations are always present, even during abnormal or emergency operations.

Airbus's philosophy appears to be that automation generally knows better than the pilot and should, under most circumstances, have the final decision authority. Boeing takes the view that the pilot is best able to evaluate individual, and possibly unique, operational circumstances and should make the ultimate decision. While Airbus' design protects the aircraft from inadvertent pilot error during normal flight, Boeing's more directly addresses abnormal and emergency operations, in the belief that under some circumstances it is better to allow the pilot to "bend" the aircraft than to potentially increase the risk of a crash.

Another difference between the two aircraft is in the flight control systems. In the Airbus design, one pilot does not see the other pilot's sidestick inputs reflected in movement of his or her own sidestick; instead, the sidesticks move independently of each other. By contrast, when one pilot of a Boeing aircraft moves his or her yoke, the movement is mirrored by the other yoke.

Airbus's lack of cross-cockpit feedback from one pilot to the other was a contributing factor in the 2009 crash of Air France flight 447 into the Atlantic Ocean, according to official findings by French investigators.

Also in the Airbus design, autopilot inputs go unseen by the pilots because the sidesticks do not move in response to the autopilot commands. Similarly, autothrottle inputs do not move the throttle levers, designs that collectively contribute to lack of automation transparency. In Boeing's fly-by-wire design, autopilot and autothrottle inputs are also seen in yoke and throttle lever movements. Also, the Boeing design adds artificial forces and electromechanical systems to retain the traditional "feel," or aerodynamic feedback, of flying the airplane, something Airbus lacks. All this provides the Boeing pilot with a more intuitive insight into what the aircraft is do-

"Boeing flight decks are designed to provide automation to assist, but not replace, the flight crew member responsible for safe operation of the airplane."

— Boeing

ing, improving automation transparency and situational awareness.

More complex automation systems, such as Airbus', can lead to degradation of human performance. Automation complexity requires more analytically demanding decision making by pilots, which in turn increases cognitive workloads. Automation complexity also results in increased lack of automation transparency, which is more likely to lead to automation confusion.

This, in turn, increases the potential for eroding both the pilot's situational awareness and basic flying skills — setting off a counterproductive spiral of automation dependency and its consequences. A 2013 FAA report acknowledged this risk when it cautioned that pilots "sometimes rely too much on automation and may be reluctant to intervene" because of a lack of understanding of the automation.

All of these concerns are exacerbated when automation fails. The Air France crash report made clear that the pilots were confused by the automation and cognitively overloaded. In that accident, the A330's autopilot disconnected after ice crystals blocked speed sensors called Pitot tubes. In the minutes that followed, according to the accident report, the pilots' failure to understand the situation and the "de-structuring of crew cooperation fed on each other until the total loss of cognitive control of the situation."

It's true that the pilots' lack of understanding of the automation was, partly, to blame for this accident, but it is also true that the automation complexity and lack of transparency shared blame for the pilot's lack of understanding. Thus, Boeing's philosophy of automation simplicity is a distinct advantage.

While computers may be gaining on the human brain, it remains the most capable, flexible and adaptable complex processor in the world. I've seen through my research what a properly trained pilot is capable of when challenged by the unexpected and properly supported by automation.

As a human factors professional, my purpose is to support pilots and to promote safe and efficient flight operations. In my view, Boeing's automation philosophy best accomplishes that goal.

Boeing

Pilots in a Boeing cockpit, such as in the 787 Dreamliner, move a yoke to command the aircraft. Those movements are mirrored in the other yoke, which provides cross feedback between the pilots.

Both Airbus and Boeing build excellent, state-of-the-art aircraft, as can be measured, in part, by their relatively equal operational and business successes. And truthfully, neither company's philosophy is completely right or wrong all of the time, under all operational circumstances. Both have strengths and weaknesses. What matters most going forward in this debate is that the manufacturers continue to update their designs and philosophies as research and operational experience continue to better inform how humans and machines work most harmoniously. And while the two will likely never share a common automation philosophy, if both do this in an open-minded manner, their philosophies may just move a bit closer together. It is this quest for improvement that defines the continuing operational frontier in aviation cockpit automation.

"All aircraft have physical limits that they must not exceed... These limits define the flight envelope, not to be exceeded during normal operation."
—Airbus

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All-seeing

Before aircraft can fly without pilots at the controls, they'll need to be equipped with sensors and computers capable of performing like the world's most sophisticated information processing system — the human eyes and brain. Keith Button shows how close, and not so close, researchers are to replicating that.

By Keith Button
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Equipping an aircraft with imaging system to "see" is akin to handing over car keys to teenagers: You can't quite trust them to notice everything on the road or anticipate every looming hazard.

If a pilotless helicopter, for instance, is choosing a landing site on its own, it needs to know that what it at first may sense to be a smooth, level, wide field ideal for touching down is actually a lake, or a canopy of tree tops.

The dual challenge for researchers working on autonomous flight systems — in which the pilot is either not on board or not operating the aircraft or simply getting help with flying — is finding the right mix of sensors to "see" around the aircraft as well as developing software to interpret what to do with that data.

Autonomous systems can already pilot a fixed-wing aircraft at altitude under benign conditions, away from obstacles. Digital flight-control systems — using sensors, though not imaging — can stabilize an unstable aircraft by calculating and executing flight control changes at 30 times or more per second, far more precisely than a human pilot could ever accomplish with stick movements.

Researchers are close to mastering the imaging-systems piece of autonomous flight, says Michael Francis, chief of ad-

Sikorsky

Sikorsky Autonomous Research Aircraft flew a simulated cargo mission in 2014 equipped with sensors to avoid obstacles as it took off, flew low to the ground, and identified and landed in a safe spot.

vanced programs at United Technologies Research Center, an arm of United Technologies Corp., and an American Institute of Aeronautics and Astronautics fellow. The more difficult problem is how to incorporate the imaging-sensor data into decision-making algorithms.

"It's not the vision piece; it's not the sensing piece itself that is the challenge today," Francis says. "And I'm not saying we can't get better at vision; I think we can. But the way that the system makes sense of that image at a given point in time—it's that stage and beyond, to me, that is the challenge."

The strategy for helicopter maker Sikorsky in developing autonomous flight systems is to create a "multi-layer world model" with software that correlates and fuses all of the images and other relevant data. In other words, according to Igor Cherepinsky, Sikorsky's chief engineer of the autonomy program, "we try to emulate what the human brain does."

"Most humans, if they were to drive or walk, if you close your eyes, you obviously don't immediately fall over or run into a wall in the car, because you have a mental picture of what's around you," he says. "Your brain is tracking other vehicles around you, it's tracking your own path, and doing some predictive work to say:

'Hey, I know there was a car behind me, the car was trying to pass me.'"

For computers, the most-difficult-to-mimic ability of the human brain will be reacting and responding quickly to the unknown — contingencies that programmers didn't plan for. Ultimately, researchers say, autonomous flight systems may always include a human connected to oversee and make judgments when complex, unforeseen circumstances arise.

Sikorsky tests its autonomous flight systems on an S-76B helicopter, called SARA, for Sikorsky Autonomy Research Aircraft. The SARA program began in 2013, when Sikorsky installed a fly-by-wire kit on the helicopter. Last year, Sikorsky tested simulated cargo missions where onboard computers used LIDAR (light detection and ranging) sensors and other sensors in a perception system to avoid obstacles as the SARA aircraft took off, flew low within 300 feet of the ground, picked suitable landing spots and set down.

This year, Sikorsky is focused on flying lower and faster, and avoiding obstacles like towers and buildings. The aircraft flies its test flights in upstate New York, based out of Duchess County Airport.

Sikorsky is working for DARPA on the agency's Aircrew Labor In-Cockpit Automation System, named ALIAS, for a wide variety of aircraft. The goal of ALIAS is to develop automated systems that can be installed in existing aircraft to reduce pilot workload, and improve performance and safety.

The ALIAS program is focused on systems that could replace the second pilot in two-pilot cockpits, with an initial focus on fixed-wing aircraft, said Mary Cummings, an associate professor at Duke University who is working on the DARPA program.

Sikorsky will initially be demonstrating the human-machine interface of SARA, using its hardware with ALIAS software, and testing it on flights coming up in the next month or two with a kit that could be put in different types of helicopters.

The algorithms and sensors required for autonomous flight with fixed-wing and rotary-wing aircraft are very similar.

"At the control system level, there's a difference. Once you get past the control system, once you can control the vehicle, it's pretty much identical," Cherepinsky says.

The base sensor in Sikorsky's model is LIDAR, which is like a laser range finder, but one that creates thousands or millions of readings at a time, with each reading creating a point in space, and each of those points with three-dimensional coordinates.

Sikorsky augments LIDAR, which provides range information but nothing about the color of objects, with various visual sensors and radar. An RGB (red, green, blue) camera can provide the color information, and shortwave infrared cameras, radars and other sensors can augment the picture further, Cherepinsky says.

Usually, with a fixed-wing aircraft, the destination is known — such as an airport runway for a passenger jet. LIDAR can detect the painted markings on the runway pretty easily, based on the reflective difference of painted versus unpainted surfaces. But rotary-wing aircraft must be able to fly to unprepared or confined landing sites — such as a field that hasn't been used for landings previously, or hasn't been selected for a landing before the flight. That's where color can become an important factor to consider, to distinguish for instance between types of vegetation and water, for example. LIDAR will sometimes miss the presence of liquid water entirely.

"If LIDAR just gives you 'The site is flat,' that doesn't necessarily mean much," Cherepinsky says. "You've got to make sure it can support your weight. You have to make sure you're not just scanning the top of a tree canopy. There's a whole bunch of other caveats that are difficult to

It's not the vision piece; it's not the sensing piece itself that is the challenge today. The way that the system makes sense of that image at a given point in time — it's that stage and beyond, to me, that is the challenge.

Michael Francis
United Technologies Research Center

Sikorsky

Sikorsky has worked with the U.S. Army on modifying Black Hawk helicopters for autonomous flight. Sikorsky is also working for DARPA to develop automated systems that could replace the second pilot in a wide variety of aircraft.

distinguish with just a pure LIDAR. So that's where both visual and shortwave infrared really helps."

In the case of a mushy landing surface, shortwave infrared and visual cameras can help identify whether it is solid enough for a landing. What's more, as a last defense, the helicopter can physically sense if a surface begins to give way too much as the aircraft touches down and aborts the landing.

The world model also tries to mimic how the human brain classifies and knows what the sensors are seeing.

"When you look at an object, in your brain, you don't really store thousands of facets or angles or the mesh that makes up the object. You look at the object and say, 'I know what that is. That's a building.' Or, 'I know what that is. That's a bush.'" Cherepinsky says. "That's what our world model is trying to do."

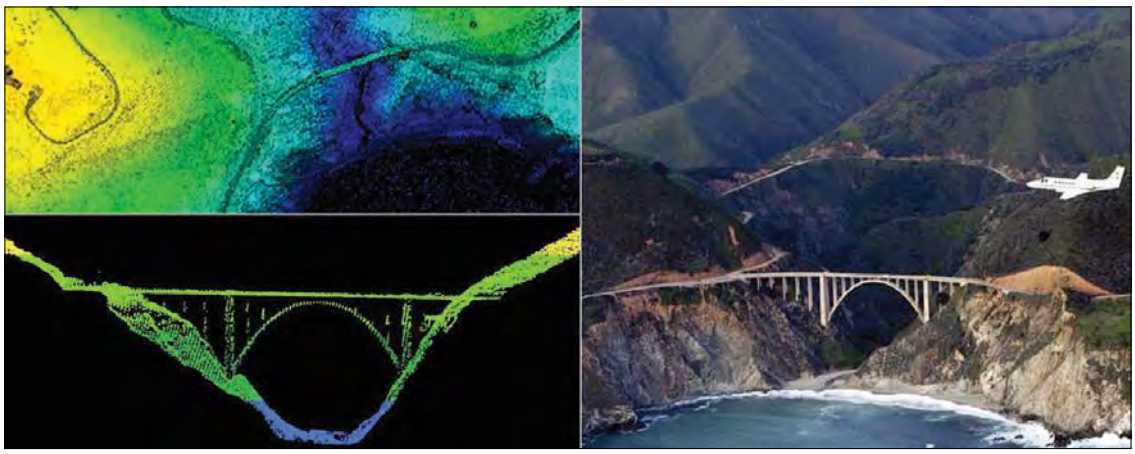
The task is difficult. Before the software that classifies an object can recognize that object, the program stores the raw data about the object so the planning system of the aircraft can avoid or not avoid it, based on the mission parameters. But the goal of the world model is to classify everything in the scene, whether it is a building, a bush or a flat spot that fits all of the characteristics required of a landing zone.

The see-and-avoid issue with other aircraft in flight — especially when Automatic Dependent Surveillance-Broadcast transponders on other aircraft aren't working — is also a difficult hurdle for developers of autonomous flight systems.

Perception-based see-and-avoid systems use the same package of sensors that scan the ground for landing sites to scan the sky. "The key here is that we really don't want to add a particular sensor for one particular task, because the cost and weight of the system quickly becomes out of [range] of what a normal customer can afford," Cherepinsky says.

Programmers for the SARA system write algorithms that incorporate two things: the world model, or outside world picture, and the mission's goals and constraints. A cargo mission for example has parameters for the cargo's current location and where it's going, and where it has to avoid no-fly zones. It also has to consider the constraints of the helicopter, including how much power is available.

Software called the mission executor — with the help of planning systems, including flight path planning and communication planning — is planning and replanning the mission, in real time, incorporating all of the information and the changing world



Autonomous flight systems can use light detection and ranging, LIDAR, to produce thousands of three-dimensional data points depicting the surrounding environment. A NOAA survey aircraft scanned the Bixby Bridge in Big Sur, California.

NOAA

model as objects and new conditions appear and change.

The question of how many, and which, sensors to use is common for all developers of autonomous pilot systems, whether they are for aircraft or for self-driving cars, Cherepinsky says.

"Too many sensors will drive up the cost of a system, but a single-sensor system is inadequate," he says. "This really is about sensor fusion, and understanding the limits of sensor fusion, and making sure that the autonomous system — the path planning system and mission planning system — have those limits embedded in them, and are planning and executing missions accordingly."

The Office of Naval Research's Autonomous Aerial Cargo/Utility System (AACUS) program for helicopters is also based on LIDAR augmented by other sensors. The Navy's program is a response to a request by the Marines to find a safer way of transporting supplies by developing an unmanned piloting kit that could be installed on any helicopter.

The AACUS perception system consists of the scanning LIDAR, three electro-optical infrared cameras, a laser altimeter, an integrated GPS-Inertial Navigation System, and a software package for real-time processing of all the sensor data, so the program can detect obstacles and characterize the landing zone, says Max Snell, AACUS program manager.

A perception system provides a three-dimensional map to the trajectory planner, which tells the helicopter what route to fly in continuously updated sections of a route, based on changing conditions or obstacles, Snell says. The trajectory planner also reads information from aircraft's performance dynamics, so it knows how to fly the aircraft, and the general flight plan for the mission.

So far, the only limitations have been in creating the right algorithms, Snell says.

"It's the code. We haven't found that we've run out of computing power yet."

In February and March 2014 testing at Quantico, Virginia, the AACUS computer program demonstrated on two helicopters that it could land the aircraft in an unprepared landing zone, while under supervision of Marines who had received only about 15 minutes of training on a tablet computer application. The computer program was given control of the helicopters mid-flight, then selected the best choice on potential landing spots, "saw" and avoided large obstacles on the ground.

AACUS restarted integrated flight tests in May 2015 in Pittsburgh on a Bell 206 JetRanger. Instead of servos — small motorized, geared mechanisms — controlling the pilot's controls, the AACUS system produces steering commands for a human pilot to follow and physically move the aircraft's controls.

"We're refining the ability to see power lines. One of the big problems with power lines depends on the angle of incidence that your approach angle is," Snell says. Running parallel to power lines versus coming in at a perpendicular angle makes a big difference with how the sensors detect them and how that data is processed.

AACUS programmers are also building tables to classify terrain into landable and unlandable surfaces. They are developing better obstacle detection on the ground and in the air, as well as identifying objects such as

brightly colored fabric marker panels that Marines will use to mark a landing area, or smoke — used to designate landing zones and to indicate wind direction. The team is also working on how to operate in areas where GPS is blocked or otherwise unavailable.

AACUS hopes to finalize a contract that would have Aurora Flight Sciences modify a Bell UH-1H helicopter into an optionally piloted aircraft, along with installing an AACUS system in the helicopter, in 12 to 15 months. The goal is to demonstrate portability to a different aircraft.

Now, the AACUS managers are focusing on avoiding smaller and more complicated objects, such as power lines or basketball-sized objects on the ground that could impede a helicopter's skid or wheel, and landing in tighter zones with more constraints. Trickier landing spots could require the helicopter to fly over, before attempting a landing, to make sure the ground is safe, or to land from a hover instead of a running landing using a flatter angle of approach.

To progress, Snell says, AACUS programmers are improving the algorithms that process the information picked up from sensors about the objects.

Sikorsky uses high-performance computers on board SARA, and upgrades them several times per year to take advantage of the advances in computing power that periodically come on line. The smartphone industry, for example, is pushing out computing advances with greater throughput and less power usage. "We are fortunate that we are living in an age where we have a choice of computing platforms, and we take advantage of all of them."

Multi-core processing — the ability to pack multiple CPU cores on one chip and to run them in parallel — and reductions in the power needed to operate high-speed computers have enabled the advancements in autonomous flight, Cherepinsky says — having the ability of having a small supercomputer in the back of a helicopter that doesn't cost a lot, or weigh a lot, or consume much power.

TRU

3-D manufacturing's Holy Grail

Additively made parts are being incorporated into rockets and spacecraft, but engineers are cautious about using the technique for such vital applications as the propellant tanks on spacecraft that must carry people or expensive communications and scientific equipment. Henry Kenyon interviewed experts at two companies that have different manufacturing approaches but a common goal: To convince customers to trust additively made components.

NASA

When a NASA Orion capsule lifts off in 2018 for the program's second unmanned test flight, the event won't just mark the space agency's return to human space flight after the retirement of the space shuttles. It will signal the beginning of a new way to build spacecraft. Fifteen percent of the components in the capsule will be made through additive manufacturing — metal and polymer structures and components constructed precisely, layer by layer from laser- or electron-beam welded powders, plastics and metals. Traditionally, everything from small parts, such as antenna brackets to propellant tanks rockets and satellites, have been made by technicians who machine away material from solid blocks of metal, using a variety of precision machine grinders. Making parts additively promises savings over traditional machining because fewer individual parts are needed to make a component, which saves weight and material and reduces the number of potential failure points.

For now, the 40 additively manufactured parts in Orion will be limited to non-mission critical components such as vents designed to equalize the pressure behind the capsule's thermal protection system with the pressure in the rest of the cap-

by Henry Kenyon
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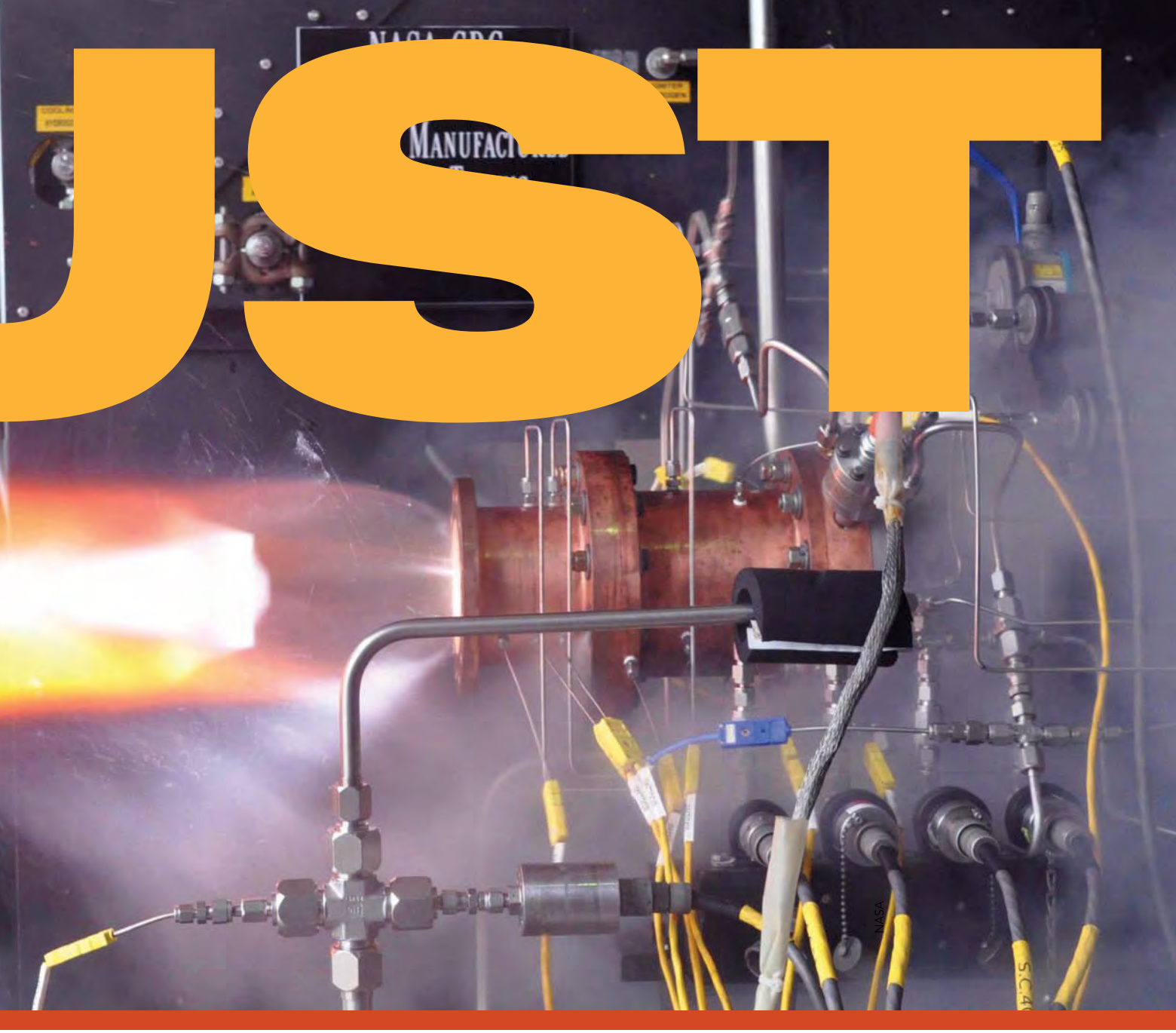


At NASA Glenn Research Center's Rocket Combustion Laboratory in Cleveland, the agency tests a rocket engine with an additively manufactured gas injector assembly made by Aerojet Rocketdyne.

sule. These parts were flown on the December 2014 unmanned Orion test flight and eventually will be a part of manned missions, NASA says. Bigger savings will extend beyond Orion to the rocket it will ride on, NASA's Space Launch System, as the agency plans to make titanium propulsion tanks and entire rocket engines with additive manufacturing technology.

The Orion plan reflects an industry-wide trend of cautiously incorporating such parts into spacecraft and rockets, the ultimate goal being to convince customers that they can trust additive manufacturing with the lives of astronauts and the fate of multibillion-dollar communication satellites and space probes.

BIG METAL, SMALL METAL

Additive manufacturing is so new that leading manufacturers of rockets and satellites are still figuring out the best techniques to make metal structures capable of withstanding the rigors of launch and the harsh vacuum environment of space. Such is the case with Aerojet Rocketdyne and Lockheed Martin.

Both companies rely on a powder-based process to build smaller components. A robotic arm lays down layers of metal powder that are fused into shape by a laser, and the arm then deposits another layer of powder to be fused. But their techniques diverge when it comes to making large components. Aerojet Rocketdyne uses a scaled-up version of the powder-based

method to manufacture rocket engines, while Lockheed Martin builds big parts like propellant tanks from large strands of titanium wire welded into shape with a high-energy beam.

Slade Gardner, a Lockheed Martin fellow focusing on advanced manufacturing and materials, refers to the powder bed method as "small metal," because it typically is used to make such parts as mounting brackets for communications antennas. He calls the alternative wire-fusing process "big metal," and his company hopes to someday make tanks that way for Orion and other spacecraft.

Aerojet Rocketdyne, by contrast, likes the powder-based system even for large items, such as nozzles, fuel injectors and ultimately entire engines.

Lockheed Martin

The Sciaky electron beam additive manufacturing machine is the largest 3-D printer in use at Lockheed Martin Space Systems in Denver.

Despite the differences, the companies have similar construction setups, with clusters of computer-controlled additive manufacturing machines working in concert to make parts. At Lockheed Martin, the big metal construction gear consists of a large vacuum chamber containing a robotic arm from Chicago-based Sciaky, Inc. It has an attached feeder containing a 100-pound spool of titanium wire and an electron gun. A vacuum is necessary for the electron gun to fuse the wire into shape. The arm moves along ceiling-mounted slides that allow it to move back and forth, left to right in what resembles a very large version of a desktop fabrication device, Gardner explains. The working chamber also contains a table that can tilt and move side to side, permitting the arm to build complex shapes.

When the electron gun fuses the titanium wire, it creates a bead of metal. As layers of wire are put down, the resulting surface is rough and much thicker than the target width of what will be a lightweight structure. A second robotic arm trims away the excess metal and machines the walls down to their proper thickness.

"Inherently it's still a welding process. If you imagine the way that really beautiful weld beads look, they have some flow to them. We cannot achieve smooth wall surfaces using this deposition process," Gardner says.

To build a propellant tank, a satellite or rocket, the Sciaky wire-deposition gear builds two domes and a central "barrel" section. A grinder mounted on a robotic arm then machines the three parts to remove excess material and to achieve the desired thickness of .02 to .04 inch before they are welded together.

So far, Lockheed Martin has built a 16-inch diameter prototype propellant tank, as well as parts for a 33-inch diameter tank. The prototype tanks are built to the requirements of the company's A2100 communications satellite frames. It takes about 15 hours to get a tank to its basic shape, with each dome and barrel requiring roughly three hours to construct. The entire process from construction to machining, welding, and final testing takes roughly a month, Gardner says. This is a great improvement over the traditional method of making a tank, which required forging a mushroom-shaped dome of titanium and machining it down to size. The forging process requires a lengthy lead time, up to 12 months and tank sizes are limited to less than 50 inches in diameter due to the cost

and expense of making the dies and presses. Plus, with additive manufacturing, engineers can change a product by adjusting the digital blueprint that the robotic equipment follows, rather than having to make new dies and presses. Additive manufacturing eliminates the long wait times and the size limitations for making titanium propellant tanks, because it's easier to adjust robotic arms in the chamber than to adjust conventional tools to make a new component. "You can build a bigger vacuum chamber for a lot less money than building a bigger forging press," Gardner says.

Aerojet Rocketdyne's powder-bed deposition process chamber resembles a large sandbox, but the sand is a specific mix of metal powders that are fused with a laser into the desired shape, explains Jay Littles, director of advanced launch programs at Aerojet Rocketdyne in Huntsville, Alabama. Depending on the component, the powder can be titanium or nickel alloys such as Inconel, or copper. Construction takes place in a vacuum chamber or one filled with an inert gas, using a machine provided by Concept Laser Inc. of Grapevine, Texas, the U.S. subsidiary of the German additive equipment company.

A turning point for Aerojet Rocketdyne came in 2014 when it test fired a subscale version of its RS-88 Bantam engine on the ground. Whereas the Baby Bantam generated 5,000 pounds of thrust, Aerojet Rocketdyne has now additively built a 30,000-pound thrust, regeneratively cooled version of the Bantam. The company has also manufactured a full-scale integrated injector assembly for possible use on its RL10 engines. Rocketdyne has also manufactured a full-scale regeneratively cooled copper chamber for an 18,000-pound thrust liquid oxygen/liquid hydrogen upper stage engine and is preparing to demonstrate a slightly larger additively manufactured engine in the 25,000 to 35,000 pound thrust range, Littles says.

ALMOST READY FOR FLIGHT

Aerojet Rocketdyne and Lockheed Martin are working on incorporating more additively manufactured parts in current and upcoming satellite and rocket projects. This will be a gradual process, say Littles and Lockheed Martin's Brynn Watson, vice president of engineering operations in Sunnyvale, California. Beyond making more parts for spacecraft, manufacturers are looking at redesigning their entire industrial processes. Lockheed Martin has an integrated design-to-construction process called the digital tapestry that combines rapid software-based testing and modeling with 3-D printed prototypes and parts. The company is also considering investing in "clusters" of additive manufacturing robots to speed production with the long-term goal of being able to essentially print an entire spacecraft. "Our 3-D printing capability is evolving," Gardner says. "We're starting with propulsion tanks and will progress onto other elements. We eventually plan to include other parts and systems, like the structure for heat shields."

Lockheed Martin expects to fly its first additively manufactured large components, such as propulsion tanks, within five years.

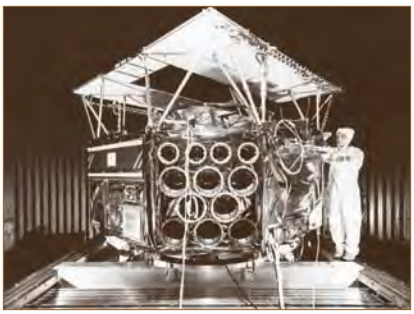
Aerojet Rocketdyne is also restructuring its design and construction processes. The company has spent the last half decade investing in 3-D construction techniques for developing components for rocket engines and other spacecraft parts. This process is now poised to begin moving to operational missions. "We are at the point to really start reaping the benefits of the significant investments we've made over the past four or five years," Little says.

A Sciaky 3-D manufacturing machine, located at the Lockheed Martin Space Systems plant in Denver, makes a propellant tank for a satellite. The machine unspools titanium wire, which is then welded into shape with an electron beam.

Out of the

25 Years Ago, July-August 1990

July 16 Pakistan's first satellite, BADR-A, is launched by a Chinese Long March 2E. This is the first flight of the Long March 2E, a stretched Long March 2, with upgraded engines. BADR, which means New Moon in Urdu, is a 150-pound, 26-side polyhedron spherical test amateur radio communications satellite. The onboard systems fail after five weeks but much is still learned. Flight International, July 25-31, 1990, p. 5.



July 25 The first commercial Atlas rocket lifts off for a chemical release experiment in the ionosphere and magnetosphere with the Combined Release and Radiation Effects Satellite. NASA, Astronautics and Aeronautics, 1986-90, p. 333.

Aug. 1 The Soviet Soyuz TM-10 is launched with Japanese Cosmonaut Toyohiro Akiyama among its crew. It docks with the Mir space station. Akiyama returns to Earth on December 10. NASA, Astronautics and Aeronautics, 1986-90, pp. 333, 336.

Aug. 10 The Magellan spacecraft enters a polar orbit of Venus and begins its mission in which 90 percent of the planet is to be mapped using radar, since the planet is covered by a thick cloud blanket of carbon dioxide and other gases. Scientists want to learn especially if Venus was once like Earth and if the greenhouse effect takes full effect on Earth, will it be like Venus. Flight International, September 19-25, 1990, pp. 54-56.

50 Years Ago, July-August 1965

July 1 For the first time, U.S. Navy General Dynamics-Grumman F-111B variable-sweep wing fighter makes a supersonic flight up to Mach 1.2 at an altitude of 30,000 feet. During the flight, the aircraft suddenly changes the angle of its wings from a straight one of 16° used for takeoff to a maximum sweep supersonic configuration of 72.5°. The plane had flown for the first time on May 18, 1965. The New York Times, July 26, 1965, p. 38M.

July 2 The TIROS-10 weather satellite is launched by a Thrust-Augmented Delta vehicle from the Eastern Test Range into a Sun-synchronous orbit of 517 miles apogee and 458-miles perigee so it can photograph tropical hurricane-breeding areas over 60 to 80 percent of the Earth. Washington Evening Star, July 2, 1965.

July 14 The Mariner 4 space probe approaches Mars within 5,500 miles and takes the first-ever close-up photos of the red planet, revealing clear images of craters and ridges. As the pictures are received by Madrid and Johannesburg tracking stations and relayed to Jet Propulsion Laboratory, they also are sent to the Smithsonian Institution's National Air and Space Museum for inclusion in an exhibit on the Mariner program, which features a full-scale model of the spacecraft. Mars is now 134 million miles from Earth. The New York Times, July 15, 1965; NASA Release 65-231.

July 15 Captain Joseph H. Engel, USAF, and X-15 pilot, receives "astronaut wings" in an Air Force ceremony at the Pentagon for his flight in the hypersonic research aircraft on June 29 in which he reached an altitude of 280,600 feet, and therefore above 50 miles that is recognized as the boundary between the Earth's atmosphere and space. During this flight he also attained a maximum speed of 3,432 mph (Mach 4.94). Department of Defense Release 458-65.

July 16 The Soviet Union orbits its Proton 1, called at the time a "scientific space station." This is a 26,880-pound payload using a "powerful new booster" and the heaviest payload ever launched to date. As a satellite launcher, later designated in the West as the SL-9, Proton 1 is a two-stage vehicle powered by six RD-253 rocket engines of 368,200-pound thrust each, or 2.2 million pounds thrust. The second stage has 540,000 pounds thrust total, from four engines. This first payload, with cosmic ray experiments, is really a test launch and not a true space station and this stage of the vehicle decays in its orbit in October. Proton's overall design is kept secret from the West until 1986. The New York Times, July 17, 1965; David Baker, Spaceflight and Rocketry, p. 182.

July 17 North American Aviation's XB-70A No. 2 Valkyrie makes its first flight from Palmdale, California, to Edwards Air Force Base and reaches a top speed of Mach 1.4 and an altitude of 40,000 feet. The plane's wing tips are folded to the full 65° during its flight. Aviation Daily, July 20, 1965.

July 18 The Soviet Union's Zond 3 is launched. Originally intended to be sent to Mars during October to November 1964, it is sent too late for that launch window and instead is aimed toward the Moon. Its onboard TV camera later takes more than 20 photos of the Moon's far side plus three ultraviolet spectra of very good quality. New York Times, July 19, 1965, p. 1; David Baker, Spaceflight and Rocketry, p. 182.

Past

An Aerospace Chronology

by **Frank H. Winter**
and **Robert van der Linden**

July 20 The S-1B booster stage of NASA's Saturn 1B launch vehicle is static-fired for 145 seconds at the Marshall Space Flight Center, producing 1.6 million pounds of thrust. Marshall Star, July 28, 1965, p. 1.

July 20 An Atlas-Able D booster orbits three satellites simultaneously, two Vela Hotel (Sentry) nuclear detection satellites and the ORS 3-1 (Octahedron) research satellite. The former are to monitor space for violations of the nuclear test-ban treaty while ORS monitors natural radiation in space. The New York Times, July 21, 1965, p. 43.

July 30 The Pegasus 3 meteoroid detection satellite is launched by the last of the Saturn 1 boosters and is designed to measure the frequency of meteoroids in the near-Earth environment, toward the design of future manned and unmanned spacecraft. An Apollo Command and Service Module boilerplate is also launched and serves as a shroud for Pegasus 3. NASA Release 65-232.

75 Years Ago, July-August 1940

July 8 The first pressurized cabin airliner, the Boeing 307-B Stratoliner, goes into service with TWA. The plane's automatic cabin pressure system maintains low-altitude pressure conditions for passengers and crew while flying at altitudes of up to 20,000 feet. E.M. Emme, ed., Aeronautics and Astronautics, 1915-60, p. 40; Flight, July 4, 1940, pp. 6, 10.

July 12 The first commercial airline link between Juneau and Seattle is started by Pan American Airways using the "Alaskan Clipper," a Sikorsky S-42B. This service is to be conducted twice weekly throughout the summer. With the advent of winter weather, the more rugged Douglas DC-3 will be substituted to provide all-year-round service, pending delivery of the Lockheed Lodestar transports, which will take over the route in 1941. Aircraft Year Book 1941, p. 136.

Aug. 4 The first direct transatlantic crossing of 1940 is made by British Overseas Airways Corporation's Short Empire four-engined flying-boat "Clare," which inaugurates the Ireland-Newfoundland-New York route. The Clare is a strengthened Short C-class flying boat that can carry up to 48,000 pounds, compared to 40,500 pounds with the standard C class. The flight is commanded by Capt. J.C. Kelly-Rogers, with a crew of four. Flight, August 15, 1940, pp. 132-133.

Aug. 19 The North American B-25 Mitchell medium bomber prototype completes its first flight. Named after Gen. William "Billy" Mitchell, the plane subsequently becomes one of the most successful bombers of the war. Nearly 10,000 are built, and they see extensive wartime service on every major front. Gordon Swanborough and Peter M. Bowers, United States Military Aircraft Since 1908, p. 398.

Aug. 25 Édouard Michelin, the well-known founder of the French rubber tire manufacturer and staunch supporter of the French aircraft industry, dies at age 81. Over the years, Michelin built more than 2,500 military aircraft at his plant at Clermont-Ferrand. Interavia, September 3, 1940, p. 14.

Aug. 28 Italy's experimental Caproni-Campini monoplane, powered by a turbine driven by a piston engine, makes its first flight. Jonathan Thompson, Italian Civil and Military Aircraft, 1930-1945, p. 95.

100 Years Ago, July-August 1915

Aug. 11 The U.S. Naval Observatory in Washington, District of Columbia, requests the Eastman Kodak Co. to develop an aerial camera capable of operating from 3,000-6,000 foot altitudes and fitted with high-speed lens. Eugene M. Emme, ed., Aeronautics and Astronautics 1915-60, p. 4.

AIAA Bulletin

On 25 March, AIAA Executive Director Sandy Magnus spoke at a Los Angeles–Las Vegas Section dinner. Dr. Magnus shared stories about her education and work, including the powerful lesson in cooperation on the ISS. She noted that it is especially important to teach the next generation that space is reachable. From left: Michael Todaro, Public Policy Co-Chair; Rick Garcia, Membership Co-Chair; Dr. Seth Potter, Ambassador to National Space Society/Mars Society LA/A-MAN STEM Center; Dr. Nicola Sarzi-Amade, Section Chair; Dr. Sandy Magnus; Dr. Lisa Kaspin-Powell, Webmaster/Newsletter Editor; Dr. Jeff Puschell, Public Policy Co-Chair; Weston Hanoka, Programs Co-Chair and Technical Co-Chair and USAF SMC Ambassador. (Photo credit: Denise Lyons)

JULY—AUGUST 2015

AIAA Directory

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† U.S. only. International callers should use 703/264-7500.

All AIAA staff can be reached by email. Use the formula first name last initial@aiaa.org. Example: megans@aiaa.org.

Addresses for Technical Committees and Section Chairs can be found on the AIAA Web site at **http://www.aiaa.org**.

We are frequently asked how to submit articles about section events, member awards, and other special interest items in the *AIAA Bulletin*. Please contact the staff liaison listed above with Section, Committee, Honors and Awards, Event, or Education information. They will review and forward the information to the *AIAA Bulletin* Editor.

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
2015			
28 Jun–2 Jul†	**International Forum on Aeroelasticity and Structural Dynamics (IFASD)**	Saint Petersburg, Russia (Contact: Dr. Svetlana Kuzmina, +7 495 556-4072, kuzmina@tsagi.ru, www.ifasd2015.com)	
6–9 Jul	**20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference**	Glasgow, Scotland	**8 Dec14**
12–16 Jul†	**International Conference on Environmental Systems**	Bellevue, WA (Contact: Andrew Jackson, 806.834.6575, Andrew.jackson@ttu.edu, www.depts.ttu.edu/ceweb/ices)	
25–26 Jul	**The Application of Green Propulsion for Future Space**	Orlando, FL	
25–26 Jul	**Advanced High Speed Air Breathing Propulsion**	Orlando, FL	
27–29 Jul	**AIAA Propulsion and Energy 2015 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **51st AIAA/SAE/ASEE Joint Propulsion Conference** **13th International Energy Conversion Engineering Conference**	Orlando, FL	**7 Jan 15**
30–31 Jul	**Business Management for Engineers**	Orlando, FL	
30–31 Jul	**Hybrid Rocket Propulsion**	Orlando, FL	
9–13 Aug†	**2015 AAS/AIAA Astrodynamics Specialist Conference**	Vail, CO (Contact: Dr. W. Todd Cerven, william.t.cerven@aero.org, www.space-flight.org/docs/2015_astro/2015_astro.html)	
29–30 Aug	**Introduction to Space Systems**	Pasadena, CA	
31 Aug–2 Sep	**AIAA SPACE 2015 (AIAA Space and Astronautics Forum and Exposition)**	Pasadena, CA	**10 Feb 15**
7–10 Sep†	**33rd AIAA International Communications Satellite Systems Conference and Exhibition (ICSSC-2015)**	Gold Coast, Australia (Contact: Geri Geschke, +61 7 3414 0700, Geri.geschke@emsolutions.com.au, www.satcomspace.org)	**1 Apr 15**
13–17 Sep†	**34th Digital Avionics Systems Conference**	Prague, Czech Republic (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)	
22–25 Sep†	**3AF/AIAA Aircraft Noise and Emissions Reduction Symposium**	La Rochelle, France (www.aners2015.com)	**30 Apr 15**
23–24 Sep†	**19th Workshop of the Aeroacoustics Specialists' Committee of CEAS and 5th Scientific Workshop of the European X-Noise EV Network**	La Rochelle, France (www.aners2015.com)	
12–16 Oct†	**66th International Astronautical Congress**	Jerusalem, Israel (Contact: www.iac2015.org)	
26–29 Oct†	**International Telemetering Conference USA**	Las Vegas, NV (Contact: Lena Moran, 951.219.4817, info@telemetry.org, www.telemetry.org)	
27–29 Oct†	**Flight Software Workshop**	Laurel, MD (Contact: http://www.flightsoftware.org)	
2016			
2–3 Jan	**2nd AIAA CFD Aeroelastic Prediction Workshop**	San Diego, CA	
4–8 Jan	**AIAA SciTech 2016 (AIAA Science and Technology Forum and Exposition)** **Featuring:** **24th AIAA/AHS Adaptive Structures Conference** **54th AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **15th Dynamics Specialists Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Information Systems—Infotech@Aerospace Conference** **AIAA Modeling and Simulation Technologies Conference** **18th AIAA Non-Deterministic Approaches Conference** **57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **9th Symposium on Space Resource Utilization** **3rd AIAA Spacecraft Structures Conference** **34th Wind Energy Symposium**	San Diego, CA	**2 Jun 15**
25-28 Jan†	**Annual Reliability and Maintainability Symposium (RAMS)**	Tucson, AZ (Contact: Sean Carter, seancarter67@gmail.com, www.rams.org)	

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	ABSTRACT DEADLINE
14–18 Feb†	**26th AAS/AIAA Space Flight Mechanics Meeting**	Napa, CA (Contact: Ryan Russell, 512.471.4190, ryan.russell@utexas.edu, www.space-flight.org/docs/2016_winter/2016_winter.html)	
5–12 Mar†	**2016 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, Erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)	
16–20 May†	**SpaceOps 2016: 14th International Conference on Space Operations**	Daejeon, Korea	**30 Jul 15**
30 May–1 Jun†	**23rd Saint Petersburg International Conference on Integrated Navigation Systems**	Saint Petersburg, Russia (Contact: Ms. M. V. Grishina, +7 812 499 8181, icins@eprib.ru, www.elektropribor.spb.ru)	
13–17 Jun	**AIAA AVIATION 2016 (AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **34th AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **8th AIAA Atmospheric and Space Environments Conference** **16th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Flight Testing Conference** **8th AIAA Flow Control Conference** **46th AIAA Fluid Dynamics Conference** **17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **47th AIAA Plasmadynamics and Lasers Conference** **46th AIAA Thermophysics Conference**	Washington, DC	
5–8 Jul†	**ICNPAA 2016 Mathematical Problems in Engineering, Aerospace and Sciences**	University of La Rochelle, France (Contact: Prof. Seenith Sivasundaram, 386.761.9829, seenithi@gmail.com, www.icnpaa.com)	
25–27 Jul	**AIAA Propulsion and Energy 2016 (AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **52nd AIAA/SAE/ASEE Joint Propulsion Conference** **14th International Energy Conversion Engineering Conference**	Salt Lake City, UT	
12–15 Sep	**AIAA SPACE 2016 (AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA SPACE Conference** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange**	Long Beach, CA	
25–30 Sep†	**30th Congress of the International Council of the Aeronautical Sciences (ICAS 2016)**	Daejeon, South Korea (Contact: www.icas.org)	**15 Jul 15**
26–30 Sep†	**67th International Astronautical Congress**	Guadalajara, Mexico (Contact: http://www.iafastro.org/guadalajara-to-host-iac-2016)	
Oct†	**22nd Ka and Broadband Communications, Navigation and Earth Observation Conference** **34th AIAA International Communications Satellite Systems Conference**	Cleveland, OH (Contact: Chuck Cynamon, 301.820.0002, chuck.cynamon@gmail.com)	

For more information on meetings listed above, visit our website at www.aiaa.org/calendar or call 800.639.AIAA or 703.264.7500 (outside U.S.).
†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.
AIAA Continuing Education courses.

AVIATION 2016

13–17 JUNE 2016 **WASHINGTON, D.C.**

"The ability to network with people from all over these different technical areas in one place in one location where you're not running all over the place has just been terrific."

—Edgar G. Waggoner, Program Director—Integrated Aviation Systems, Aeronautics Research Mission Directorate, NASA Headquarters

AIAA AVIATION 2016 will combine the best aspects of technical conferences with insights from respected aviation leaders, providing a single, integrated forum for navigating the key challenges and opportunities affecting the future direction of global aviation policy, planning, R&D, security, environmental issues, and international markets. Twelve technical conferences in one location make this a must-attend event in 2016!

Why Washington, D.C.?

It's the perfect place to combine business and family fun. It is home to Congress, NASA Headquarters, NASA Goddard, NOAA, the FAA, NSSC, NRL, and the Pentagon. There are more than 100 free things to do in Washington, D.C.—including most of the Smithsonian (with TWO air and space museums, art galleries, and the National Zoo) and scores of famous landmarks—most within walking distance of one another.

Technical Conferences

- 32nd AIAA Aerodynamic Measurement Technology and Ground Testing Conference
- 34th AIAA Applied Aerodynamics Conference
- AIAA Atmospheric Flight Mechanics Conference
- 8th AIAA Atmospheric and Space Environments Conference
- 16th AIAA Aviation Technology, Integration, and Operations Conference
- AIAA Flight Testing Conference
- 8th AIAA Flow Control Conference
- 46th AIAA Fluid Dynamics Conference
- 17th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference
- AIAA Modeling and Simulation Technologies Conference
- 47th AIAA Plasmadynamics and Lasers Conference
- 46th AIAA Thermophysics Conference

Sign up to be notified when the Call for Papers opens.

aiaa-aviation.org/FutureEvents

AIAA

Shaping the Future of Aerospace

15-752

From the Corner Office

SYSTEMS ENGINEERING AND EMERGING TECHNOLOGIES

Thomas B. Irvine and David B. Williams

AIAA, your Institute, is moving smartly to stay relevant to you as an aerospace professional and relevant to our industry and our profession. As our industry evolves, we will grow by staying true to our core values, which are built upon technical knowledge and expertise. AIAA has always provided a meeting place where ideas can be freely and openly exchanged in an intellectually challenging, yet collegial, atmosphere. One appealing attribute of AIAA is that it brings together members from industry, government, and academia without a bias or prejudice toward any one of these constituencies. Having existed for over 50 years—over 80 if one includes legacy organizations—we are positioning ourselves to remain relevant for the next half century. Today, like never before, the convergence of technologies from the communications, information, and automation/robotics industries within aerospace systems is changing the way in which we think about designing, building, and operating aircraft and spacecraft, and the systems in which they operate. Advances in legacy engineering disciplines, such as materials sciences and manufacturing are similarly allowing us to reimagine how we do our jobs during any point of the aerospace product life cycle. Many of AIAA's members are involved in the design, development, and test and evaluation of engineered systems. A large percentage also are involved in research and development, where advances being made today will affect how we take that knowledge and engineer useful and salable products, systems, and services in the future. AIAA's Institute Development Committee recently has been discussing and deliberating about technologies and adjacent industry sectors that are affecting what we can do as aerospace professionals. By focusing our efforts on industry sectors such as commercial space, cybersecurity, advanced manufacturing, unmanned aerial system operations and rotorcraft/runway independent air vehicle technology, we will provide opportunities to learn, share, and ultimately expand our collective knowledge, uses, and novel applications of these technologies. This is the first of several columns to explore these sectors and AIAA's role in them.

Within our industry today, systems thinkers and engineers are merging and linking technologies in ways heretofore unimaginable, and in so doing, are revolutionizing our industry. Two striking examples where convergent technologies will revolutionize our industry and profession are the proliferation of unmanned aerial systems operating in the National Air Space and the ever-expanding capabilities and uses in the area of advanced manufacturing.

Small unmanned aerial systems (sUAS) are the current media darling of the aviation industry. Entrepreneurial and corporate communities, as well as government, envision using sUAS for myriad applications, making some form of sUAS traffic management a certainty. A sUAS traffic management system conceived at NASA Ames Research Center and being developed with partners from the aeronautics, communications, and IT industries will realize the vision of ubiquitous sUAS operations for the numerous services and applications that these systems can perform. AIAA is a collaborator in the upcoming UAS Traffic Management Convention 2015 to be held 28–30 July in Mountain View, CA, during which this system will be discussed in an open forum.

Within academia, the FAA has established an FAA National Center of Excellence (CoE) for UAS. Led by Mississippi State University, the Alliance for System Safety of Unmanned Aircraft Systems through Research Excellence (ASSURE) comprises the world's top UAS universities with 15 core schools and five associate members from three countries and more than 100 government and industry partners. Along with the other member schools and institutions, The Ohio State University was selected as a partner in ASSURE for reasons related to geography, history, and resident expertise. Initial research areas will include detect and avoid technology; low-altitude operations safety; control and communications; spectrum management; human factors; compatibility with air traffic control operations; and training and certification of UAS pilots and other crewmembers. Coordination among this many partners will be key to the CoE's success. To that end, Ohio State and the Sinclair National UAS Training and Certification Center will be co-hosting the first Unmanned Systems Academic Summit, focusing on UAS technological advances, research, and education on 24 August in Dayton, OH.

In the area of advanced manufacturing, techniques being used today are revolutionizing designs as we begin to use additive manufacturing techniques to make parts that defied manufacturability by traditional "subtractive" methods. The recent example of the 3D-printed ratchet and socket aboard the ISS from the start-up company Made In Space, located in Mountain View, CA, is paving the way to printing hardware for use in space, in-space recycling, and even possibly manufacturing from in situ materials. Lightweighting is another important trend impacting advanced manufacturing—especially in the aerospace and automotive industries. In 2014, a research consortium led by Columbus, OH-based EWI (the leading engineering and technology organization in North America dedicated to advanced materials joining and allied manufacturing technologies), Ohio State, and the University of Michigan was chosen by the U.S. Department of Defense to operate the Lightweight and Modern Metals Manufacturing Innovation (LM3I) program. Dubbed LIFT (Lightweight Innovations for Tomorrow), the consortium provides the commercial and military sectors with innovative solutions for lightweight subsystem design, component-level manufacturing, joining, and assembly processes and quality control methods, e.g., distortion-control during joining and heat treatment. These lightweighting solutions involve the development of cutting-edge predictive capabilities and standardized certification methods to enable accurate knowledge of microstructure and damage evolution and performance through physics-based models and advanced interrogation tools.

But LIFT won't focus on technology at the expense of talent. Its vision—to be the world leader in lightweight materials manufacturing—can only be realized if an educated and skilled workforce can use new lightweighting technologies and processes. Its plan to develop and deploy that workforce is comprehensive and spans both the continuum of jobs in manufacturing where the nation is now experiencing a "skills gap," and the continuum of education and training that must be available in communities and states seeking to sustain, grow, and attract manufacturing jobs.

At colleges of engineering within our research universities, faculty, staff, and students are being challenged to work collaboratively across departmental and even institutional lines, while at the same time doing discipline-specific research that is truly cutting edge. It is an exciting time to be working in the aerospace profession, regardless of your specific role and responsibilities. AIAA intends to progress into these and other areas that represent challenges and opportunities for our profession. With your support and participation, we can perhaps entice those in aerospace and, frankly, those from other discipline areas that are now intersecting with aerospace, to become active in AIAA. In this way, we can all benefit as we conceive, design, build, and operate aerospace systems, taking full advantage of new technologies and technology convergence opportunities.

Thomas B. Irvine serves as AIAA's managing director of Content Development. Last year, he retired as NASA's deputy associate administrator for Aerospace Research after a 32-year career at the agency.
Dr. David B. Williams is the dean of the College of Engineering at The Ohio State University. He served as aresident of University of Alabama in Huntsville from 2007 to 2011. Both are longtime members of AIAA.

CALL FOR BOARD OF DIRECTORS NOMINATIONS

The 2015–2016 AIAA Nominating Committee will meet in early September to review nominees and select candidates to participate in the Board of Directors (BoD) Election to fill the following vacancies by election in 2016:

- Vice President-Elect, Member Services
- Vice President-Elect, Technical Activities
- Director–Technical, Information Systems Group
- Director–Technical, Propulsion and Energy Group
- Director–Region IV
- Director–Region V
- Director–Region VII
- Director–At-Large
- Director–International

AIAA BoD Duties Highlights
Details to keep in mind when running for the Board of Directors:

- Volunteer Board service (commitment to attend 3–4 meetings per year in person)
- Need employer time and travel commitment
- Support Institute mission and vision
- Provide strategic discussion and input when required
- Duty to protect assets and exercise fiduciary prudence
- Serve in BoD leadership or support capacity as required
- Be vigilant of the aerospace landscape and identify business opportunities for the Institute
- Support AIAA Executive Director and staff as appropriate

AIAA members may submit themselves or other members qualified for the chosen position as nominees by submitting a nomination through the AIAA website (go to **www.aiaa.org**, log in, and select Board of Director Nomination from the left-hand navigation bar) no later than **21 August 2015**. Nominations will open 9 June 2015.

Bill Seymore
AIAA Corporate Secretary/Treasurer

CELEBRATION OF THE SUCCESSFUL REENTRY OF THE ORION SPACECRAFT USING TEXTRON'S APOLLO HEATSHIELD TECHNOLOGY

The AIAA New England Section held a celebration at Textron Systems in Wilmington, MA, on 27 April, to celebrate the dedicated efforts of Avco and Textron employees who developed, fabricated, and tested the reentry heatshield that was used to protect astronauts returning from the moon in the 1960s and 1970s and that flew last December on the Exploration Flight Test (EFT-1) of the Orion space capsule. Three of the 61 attendees, Joseph Kowal, Jack Graham, and Bruce Belason, were retirees who were part of the initial development of the heatshield for Apollo. The event was supported significantly by Emily Springer at AIAA Headquarters and Dr. Ferdinand Grosveld, AIAA Region I Director.

The guests were welcomed by Textron business managers James Tibaudo and Michelle Pelersi, who introduced a NASA Apollo film from the 1960s describing the Apollo program. Dr.

Annalisa Weigel and David Padgett presenting a certificate to one of the Textron employees who worked on Orion.

Avco/Textron employees who were part of the Apollo team are (from left) Joseph Kowal, Jack Graham, and Bruce Belason. Larry Price, Lockheed Martin's Orion Deputy Program Manager is on the right.

David Padgett, the New England Section Chair, described AIAA and its section activities. Dr Annalisa Weigel, AIAA Vice President–Membership, presented certificates to the three employees who worked on Apollo and the 21 Textron employees and contractors who worked on Orion, while Bruce Belason entertained the audience with comments about working on the Apollo program.

Larry Price, Lockheed Martin's Orion Deputy project manager, described the Orion project and NASA's future plans. He showed a video of the launch and reentry of EFT-1. Erik Takacs, Textron program manager, described Textron's heatshield build process, which was supported by a dedicated and hardworking team. Robert Knudsen, Textron's principle thermo design engineer, described the extensive array of testing performed at NASA facilities to simulate the initial skip and final reentry conditions for lunar and deep space reentry. The presentations were followed by a tour of the Orion production area where a full-scale Manufacturing Demonstration Unit (MDU) was on display.

CALL FOR PAPERS
ICNPAA 2016 World Congress: Mathematical Problems in Engineering, Sciences and Aerospace
La Rochelle, France, 5–8 July 2016

On behalf of the International Organizing Committee, it gives us great pleasure to invite you to the ICNPAA 2016 World Congress: 11th International Conference on Mathematical Problems in Engineering, Aerospace and Sciences, which will be held at the University of La Rochelle, France.

Please visit the website, **http://www.icnpaa.com**, for all the details. This is an AIAA, IFIP cosponsored event.

Congratulations to the winners of the recent Aerospace Design and Structures student paper competitions! From left: *Jefferson Goblet*: Zimi Jenmy Zhang, University of Toronto; *American Society for Composites Best Student Paper in Composites*: Broderick Coburn, University of Bristol; *Harry H. and Lois G. Hilton Best Student Paper in Structures*: Naveen Prakash, Virginia Polytechnic Institute and State University; *Lockheed Martin Best Student Paper in Structures*: Andrew Lingenfelter, Air Force Institute of Technology; and *Southwest Research Institute Student Paper Award in Non-Deterministic Approaches*: Emily Henry, Wright State University.

MEMBERSHIP ANNIVERSARIES

AIAA would like to acknowledge the following members on their continuing membership with the organization.

25-Year Anniversaries

Raymond A Lewis	Central Pennsylvania
Alok Sinha	Central Pennsylvania
William A Daniels	Connecticut
Jeff M Mendoza	Connecticut
Bruce L Morin	Connecticut
Mark A Stafford	Connecticut
Richard C Wilde	Connecticut
Dave P Cadogan	Delaware
Richard Golaszewski	Greater Philadelphia
Brahmanand Panda	Greater Philadelphia
John L Papp	Greater Philadelphia
Frank T Stoner	Greater Philadelphia
Meelan M Choudhari	Hampton Roads
Victoria I Chung	Hampton Roads
Richard DeLoach	Hampton Roads
Karl T Edquist	Hampton Roads
James R Florance	Hampton Roads
Stephen J Horan	Hampton Roads
Karen E Jackson	Hampton Roads
Thiagarajan Krishnamurthy	Hampton Roads
Andrew E Lovejoy	Hampton Roads
Sudheer N Nayani	Hampton Roads
Craig L Nickol	Hampton Roads
Matthew N Rhode	Hampton Roads
Mark E Robeson	Hampton Roads
Danesh K Tafti	Hampton Roads
Jeffery A White	Hampton Roads
Gregory J Falabella	Long Island
Sung P Lin	Long Island
Delano Carter	Mid-Atlantic
Timothy J Collins	Mid-Atlantic
James E Coolahan Jr	Mid-Atlantic
Harris L Edge	Mid-Atlantic
Erich H Mueller	Mid-Atlantic
Frederick A Tasker	Mid-Atlantic
Paul W Wells	Mid-Atlantic
John P Baird	National Capital
Gary T Bowman	National Capital
Thomas C Butash	National Capital
Christopher P Cadou	National Capital
Robert Costa	National Capital
Samuel H Dupree Jr	National Capital
Bruce Eickhoff	National Capital
Clare A Ewald	National Capital
Michael J Glogowski	National Capital
Michael P Grone	National Capital
William Grossmann	National Capital
Jason E Jenkins	National Capital
John D Kelley	National Capital
Glen T Logan	National Capital
Louis S Lome	National Capital
Timothy D Maclay	National Capital
Thomas E Maultsby	National Capital
Jason W Mitchell	National Capital
Gerald C Musarra	National Capital
David D Myre	National Capital
Angel J Oria	National Capital
Michael W Plesniak	National Capital
Wade J Pulliam	National Capital
Jeffrey A Randorf	National Capital
David T Rusk	National Capital
Robie I Samanta-Roy	National Capital
Paul J Schad Jr.	National Capital
Merrie J Scott	National Capital
Raymond J Sedwick	National Capital
John J Shottes Jr	National Capital
John M Stacy	National Capital
Steven E Sumner	National Capital
Edward V Svatek Jr	National Capital
Michael J Toll	National Capital
Michael W Vanik	National Capital
Wil Vargas	National Capital
James M Wright Jr	National Capital
Herbert R Zucker	National Capital
Richard C Zwierko	National Capital
Kenny S Breuer	New England
Peter K Cocolis	New England
Charles R Dauwalter	New England
Richard Greenspan	New England
John F Hawk	New England
Jonathan P How	New England
Charles J Nevola	New England
Basant K Parida	New England
Jean E Piou	New England
Albert Sacco Jr.	New England
Robert A Vivona	New England
Brian L Wardle	New England
John L Crassidis	Niagara Frontier
James C Morelli	Northeastern New York
Venkat E Tangirala	Northeastern New York
Kenneth D Visser	Northeastern New York
Michael Bojcik	Northern New Jersey
Richard B Miles	Northern New Jersey
Keith B Olasin	Northern New Jersey
Charles C Chen	Southern New Jersey
Nicholas V Chilelli	Southern New Jersey
Jeffrey D Keller	Southern New Jersey
Jerry M Seitzman	Atlanta
Howard S Kanner	Cape Canaveral
Teresa L Kinney	Cape Canaveral
Rohit R Patel	Cape Canaveral
Arthur L Scholz	Cape Canaveral
Kevin A Bradley	Carolina
Brian J Kirby	Carolina
James I Middleton Jr.	Carolina
David F Robinson	Carolina
Randal T Allen	Central Florida
Robert M Beard	Central Florida
Frank J Cerra	Central Florida
Jayanta S Kapat	Central Florida
Chester N Kennedy	Central Florida
Lawrence S Ukeiley	Central Florida
Theodore J Wierzbanowski	Central Florida
Stuart Wilkinson	Central Florida
ShuhJing B Ying	Central Florida
William J Coirier	Greater Huntsville
Darby G Cooper	Greater Huntsville
William E Dietz	Greater Huntsville
Jeffrey L Finckenor	Greater Huntsville
James V French	Greater Huntsville
James P Hubner	Greater Huntsville
Joseph A Huwaldt	Greater Huntsville
Stephen L Johnson	Greater Huntsville
Mohammad J Khan	Greater Huntsville
Michael A Lawler	Greater Huntsville
James R Meehan	Greater Huntsville
Lee A Miller	Greater Huntsville
Masoud Rais-Rohani	Greater Huntsville
Julie A Ray	Greater Huntsville
Joel W Robinson	Greater Huntsville
Mark L Underwood	Greater Huntsville
Peter G Valentine	Greater Huntsville
Joseph Marc Verhage	Greater Huntsville
David L Williams, II	Greater Huntsville
David J Coote	Greater New Orleans
Howard J Fleisher	Savannah
Gary M Nizzi	Savannah
Mark E Ray	Savannah
James M Burns	Tennessee
Edward J Dumas	Tennessee
Christy B Gattis	Tennessee
Robert P Howard	Tennessee
Ralph R Jones, III	Tennessee
Ronald H Kohl	Tennessee
Robert W McAmis	Tennessee
John D Schmisseur	Tennessee
Michael W Bailey	Dayton/Cincinnati
Gregory L Costa	Dayton/Cincinnati
Douglas J Dolvin	Dayton/Cincinnati
Brian T Drake	Dayton/Cincinnati
Sivaram P Gogineni	Dayton/Cincinnati
Bruce K Preiss	Dayton/Cincinnati
Gregory W Reich	Dayton/Cincinnati
Thomas E Rittinger	Dayton/Cincinnati
Joseph B Williams, Jr	Dayton/Cincinnati
Douglas W Cunzeman	Illinois
Monica Doyle	Illinois
John W Kiedaisch	Illinois
Deborah A Levin	Illinois
Farzad Mashayek	Illinois
Robert W McCarthy	Illinois
Constantine Megaridis	Illinois
M. S Anand	Indiana
Philip S Burkholder	Indiana
Robert A Ress	Indiana
Steven P Schneider	Indiana
Jeffrey R Herbon	Michigan
Charles J Jacobus	Michigan
Glen R Pollock	Michigan
Kenneth J Preston	Michigan
Khaled W Shahwan	Michigan
Lynn A Arrington	Northern Ohio
Barbara Esker	Northern Ohio
Richard E Kreeger	Northern Ohio
Stewart J Leib	Northern Ohio
Larry C Liou	Northern Ohio
Vinod K Nagpal	Northern Ohio
Steven R Oleson	Northern Ohio
Manthena S Raju	Northern Ohio
Ashwin R Shah	Northern Ohio
Peter M Struk	Northern Ohio
Matthew T Domonkos	Albuquerque
Michael R Good	Albuquerque
Dale R Hite	Albuquerque
Jason E Pepin	Albuquerque
Andrew D Santangelo	Albuquerque
Marlon E Sorge	Albuquerque
Richard E Huffman Jr	Holloman/Alamogordo
Christopher S Allen	Houston
Vatsal N Bulsara	Houston
Barry W Finger	Houston
J. L Foster	Houston
Larry J Friesen	Houston
Theodore E Goetz	Houston
Brian J Johnson	Houston
Lon F Miller	Houston
Brian O`Hagan	Houston
Michael L Raftery	Houston
Chris Y Taylor	Houston
John D Whitcomb	Houston
George S Briggs	North Texas
Paul W Finnegan	North Texas
Chaoqun Liu	North Texas
Dale E Tietz	Southwest Texas
James D Walker	Southwest Texas
Samuel W Ximenes	Southwest Texas
David K Holger	Iowa
Clayton M Jones	Iowa
Ping Lu	Iowa
Paul J Bradley	Rocky Mountain
Wilbert F Craig, III	Rocky Mountain
Andrew H Grimes	Rocky Mountain
Barry A Hamilton	Rocky Mountain
Mitchell K Hobish	Rocky Mountain
William C Jackson	Rocky Mountain
Monte F Kopke	Rocky Mountain
Stephen R Pirman	Rocky Mountain
Bradford J Rice	Rocky Mountain
Jeffrey A Schnackel	Rocky Mountain
Richard F Moomaw	St. Louis
Douglas G Schwaab	St. Louis
Jerry J Sellers	Rocky Mountain
Steve W Stivers	Rocky Mountain
Paul M Stoltz	Rocky Mountain
Victor W Whitehead	Rocky Mountain
Gary J Hanus	Twin Cities
Vojin R Nikolic	Twin Cities
Phillip J Andrews	Wichita
David J Bernstorf	Wichita
Steven A Hawley	Wichita
John A Offerman	Wichita
Dave W Whinery	Wichita
Z Charlie Zheng	Wichita
nthony R Pilon	Antelope Valley
Brenda K Rasmussen	Antelope Valley
Donald N Williams	Antelope Valley
Myles L Baker	Los Angeles-Las Vegas
Edward J Beiting, III	Los Angeles-Las Vegas
Richard A Fowell	Los Angeles-Las Vegas
Joe Freitag	Los Angeles-Las Vegas
James H Hilbing	Los Angeles-Las Vegas
Alan B Jenkin	Los Angeles-Las Vegas
Brian R Kramer	Los Angeles-Las Vegas
Kurt B Kreiner	Los Angeles-Las Vegas
Steven P Kuritz	Los Angeles-Las Vegas
Peter D Lohn	Los Angeles-Las Vegas
Douglas W Pentecost	Los Angeles-Las Vegas
Robert D Sechrist	Los Angeles-Las Vegas
Massoud Sinai	Los Angeles-Las Vegas
Steve Smith	Los Angeles-Las Vegas
Larry N Berge	Orange County
William G Burnett	Orange County
Raymond P Fuller	Orange County
Donald Graves	Orange County
Scott W Landry	Orange County
Hugh D MacInnes	Orange County
David V Shuter	Orange County
Rhonda A Slattery	Orange County
James D Trolinger	Orange County
Roberto Albertani	Pacific Northwest
Julie A Arndt	Pacific Northwest
Kevin P Barr	Pacific Northwest
Philip G Cooper	Pacific Northwest
William A Creel	Pacific Northwest
Glen P Doggett	Pacific Northwest
Frode Engelsen	Pacific Northwest
Clifford K Forester	Pacific Northwest
James A Fort	Pacific Northwest
Jonathan H Gosse	Pacific Northwest
Robert C Griffiths	Pacific Northwest
John C Helm	Pacific Northwest
Kevin Leath	Pacific Northwest
Charles L Norman IV	Pacific Northwest
Luis A Bohorquez	Phoenix
Kenneth R Darling	Phoenix
Armando A Rodriguez	Phoenix
Mark E Strickland	Phoenix
George E Zurmehly	Phoenix
Daniel W Bursch	Point Lobos
Bill R Lawver	Sacramento
Chiping Li	Sacramento
Walter E Ainslie	San Diego
Phillip C Birkhahn	San Diego
Rodney E Stubbs	San Diego
Matthew M Bennett	San Fernando Pacific
Sean Buckley	San Fernando Pacific
David H Burde	San Fernando Pacific
Atherton A Carty	San Fernando Pacific
Stephen C Jensen	San Fernando Pacific
Knut I Oxnevad	San Fernando Pacific
Manuel T Silvia	San Fernando Pacific
Scott T Vogt	San Fernando Pacific
Joe A Blanche	San Francisco
Glen D Carl	San Francisco
Richard A Coppenbarger	San Francisco
Charbel Farhat	San Francisco
Melissa A Farrell	San Francisco
Irene S Huang	San Francisco
David J Levitt	San Francisco
Stuart L McHugh	San Francisco
Christopher J Menke	San Francisco
Peter E Nelson	San Francisco
Juanita V Ryan	San Francisco
Eric Tilenius	San Francisco
Ted B Wertheimer	San Francisco
Jeffrey A Beck	San Gabriel Valley
Jairus M Hihn	San Gabriel Valley
Danny D Howard	San Gabriel Valley
Daniel J Levack	San Gabriel Valley
Jon A Sims	San Gabriel Valley
Saravan Sutharshana	San Gabriel Valley
Jeffery N Webster	San Gabriel Valley
Scott E Coleman	Utah
Donald R Sauvageau	Utah
Nicholas J Whitehead	Utah
Dianne J DeTurris	Vandenberg
Fred F Afagh	International
Mohammad F Al-Malki	International
Masahiro Atsumi	International
Monika Auweter-Kurtz	International
Jorge M Barata	International
Jose E Barros	International
Eduardo M Belo	International
Jeremy J Benton	International
Eduardo W Bergamini	International
Gustavo C Bodstein	International
Keeyoung Choi	International
James K Chu	International
Gennaro Colabatistto	International
Luis Fernando F Da Silva	International
William N Dawes	International
Ann P Dowling	International
Dimitrios Drikakis	International
Walter Flury	International
Tony J Forward	International
Hisao Futamura	International
Rizwan Gulamhussein	International
Ismet Gursul	International
Itaru Hataue	International

Ryan Hunninghaus	International
Toshiyuki Itoko	International
Mohsen Jahanmiri	International
Leslie J Johnston	International
Hartmut J Kentgens	International
Shinya Kobayakawa	International
Dennis A Krogman	International
Masataka Maita	International
Mahmoud Mani	International
Daisaku Masaki	International
Goro Masuya	International
Kisa Matsushima	International
Saburo Matunaga	International
Josua P Meyer	International
Etsuo Morishita	International
Benveniste Natan	International
Cheok H Ng	International
Eliahu Nissim	International
Fabrizio Paganucci	International
Marius Paraschivoiu	International
Dario Pastrone	International
Nigel Peake	International
Anthony J Ponton	International
Ishwar K Puri	International
Uwe Riedel	International
David C Riordan, II	International
Giorgio Saccoccia	International
Peter W Sacher	International
Akihiro Sasoh	International
Martin J Schaffar	International
Takashi Shimomura	International
Andreas Singer	International
Roy S Smith	International
Robert A Stowe	International
Hirokazu Tahara	International
Hiroyuki Takano	International
Jose P Tamagno	International
Nigel J Taylor	International
Renato Tognaccini	International
Hiroshi Torii	International
Pierre F Trichet	International
Masazumi Ueba	International
Akira Urita	International
Bor-Tsuen Wang	International
Semyung Wang	International
Atsutaro Watanabe	International
Peter Watzka	International
Warren R Williams	International
Gregoire S Winckelmans	International
Nobuhiko Yamasaki	International
Koetsu Yamazaki	International
Xin Zhang	International

40-Year Anniversaries

Roger A Lucheta	Central Pennsylvania
Alan Epstein	Connecticut
James S Johnson	Connecticut
Roy F Albang	Hampton Roads
H Lee Beach Jr.	Hampton Roads
Pieter G Buning	Hampton Roads
J. Philip Drummond	Hampton Roads
Clyde L Edwards	Hampton Roads
Michael J Hemsch	Hampton Roads
E. C. Kilgore	Hampton Roads
Vladislav Klein	Hampton Roads
John E Lamar	Hampton Roads
Laurence D Leavitt	Hampton Roads
Martin M Mikulas Jr.	Hampton Roads
Charles G Miller III	Hampton Roads
David E Reubush	Hampton Roads
James C Robinson	Hampton Roads
David H Rudy	Hampton Roads
Richard J Silcox	Hampton Roads
William J Small	Hampton Roads
Raymond D Whipple	Hampton Roads
David G Korn	Long Island
Maris Lapins	Long Island
David S Paris	Long Island
G Richard Eisler	Mid-Atlantic
John G Gregory	Mid-Atlantic
Robert H Koons	Mid-Atlantic
John Kuhlman	Mid-Atlantic
James D Lesikar	Mid-Atlantic
Lee S Simkins	Mid-Atlantic
James H Babcock	National Capital
Raymond F Ball	National Capital
Richard J Driscoll	National Capital
William J Guit	National Capital
W. Michael Hawes	National Capital
Peter V Hwoschinsky	National Capital
Louis A Kleiman	National Capital
Peter M Kutemeyer	National Capital
Stuart Matthews	National Capital
Douglas Olsen	National Capital
Kenneth E Uffelman	National Capital
Michael F Zedd	National Capital
Christophe P Krebs	New England
Yuan Pang	New England
Daniel W Swallom	New England
Philip P Beauchamp	Northeastern New York
Hussein E Khalifa	Northeastern New York
John M Wilson	Atlanta
Warren G Heller	Carolina
William E Holley	Carolina
Giovanni Bonfanti	Central Florida
Robert T Galloway	Central Florida
Ralph D Kimberlin	Central Florida
Ricky E Ort	Central Florida
Wayne A Pence	Central Florida
Robert E Pierce	Central Florida
Ray S Applebaum	Greater Huntsville
John E Burkhalter	Greater Huntsville
Lanier S Cauley	Greater Huntsville
Basil P Cooper	Greater Huntsville
John O Lassiter	Greater Huntsville
G. Alan Lowrey	Greater Huntsville
Mark Seaford	Greater Huntsville
Don E Simpson	Greater Huntsville
Michael J Witt	Greater New Orleans
William R Bushelle	Northwest Florida
Jeff W Rish, III	Northwest Florida
Corso Padova	Columbus
Milton E Franke	Dayton/Cincinnati
Anthony N Palazotto	Dayton/Cincinnati
George C Perley	Dayton/Cincinnati
Michael F Ryan	Dayton/Cincinnati
Sundaresa V Subramanian	Dayton/Cincinnati
Glen J Kissel	Indiana
William G Knorr	Indiana
Roy K Amiet	Northern Ohio
Guion S Bluford	Northern Ohio
Steven J Schneider	Northern Ohio
Patrick J Stiennon	Wisconsin
Roger A Tennant	Albuquerque
Randy Truman	Albuquerque
David P Abuisi	Houston
Charles J Camarda	Houston
Barbara R Counts	Houston
Lawrence T Guderian Sr	Houston
Nicole O Lamotte	Houston
Renee J Lance	Houston
Carla J Yager	Houston
Edward K Hensley	North Texas
Milton W Holcombe	North Texas
Kenneth R Meyers	North Texas
J Christopher Wilt	North Texas
O Hal Burnside	Southwest Texas
Paul A Carver	Southwest Texas
Vincent D DiLoreto	Southwest Texas
Keith A Holden	Southwest Texas
Lyle E Bareiss	Rocky Mountain
Albert C Brandts	Rocky Mountain
Donna S Gerren	Rocky Mountain
Bryan Soderberg	Rocky Mountain
Ian A Whalley	Rocky Mountain
Kevin D Citurs	St. Louis
Raymond R Cosner	St. Louis
Alfred L Crosbie	St. Louis
Eugene J Cunningham	St. Louis
Robert M Dowgwillo	St. Louis
Richard D Taylor	St. Louis
Robert R Boroughs	Wichita
Gary D Park	Wichita
James T Sturdy	Wichita
Emory H Hall, Jr	Antelope Valley
James A Wildemann	Antelope Valley
Edward L Jeter	China Lake
Allen A Arata	Los Angeles-Las Vegas
Brad L Carlson	Los Angeles-Las Vegas
Edward N Danielsen	Los Angeles-Las Vegas
John E Fidler	Los Angeles-Las Vegas
Thomas F Heinsheimer	Los Angeles-Las Vegas
Kenneth W Iliff	Los Angeles-Las Vegas
John E Kulpa, Jr.	Los Angeles-Las Vegas
William C Shih	Los Angeles-Las Vegas
Satya N Atluri	Orange County
Daryl L Bahls	Pacific Northwest
Michael B Bragg	Pacific Northwest
John M Fabian	Pacific Northwest
Esat N Guzey	Pacific Northwest
Peter Halamek	Pacific Northwest
Charles W Lee	Pacific Northwest
John W Moore	Pacific Northwest
Basil S Papadales	Pacific Northwest
Joao Miguel Santos	Pacific Northwest
Thomas E Speer	Pacific Northwest
Michael L Warden	Pacific Northwest
Ronald L Alto	Phoenix
Lysbeth S Lieber	Phoenix
Kevin Owen	Point Lobos
Mohamed M Hafez	Sacramento
Peter L Boland	San Diego
Nagy S Nosseir	San Diego
James H Estes	San Fernando Pacific
Allen L Goldman	San Fernando Pacific
Brian Granger	San Fernando Pacific
Theodore J Schuldt	San Fernando Pacific
James M Shoji	San Fernando Pacific
Roger T Anderson	San Francisco
Francis X Caradonna	San Francisco
Terry L Holst	San Francisco
Wayne Johnson	San Francisco
Hirokazu Miura	San Francisco
Takashi Nakamura	San Francisco
Michael P Scully	San Francisco
Surendra P Sharma	San Francisco
Jose L Spencer	San Francisco
Thomas L Trankle	San Francisco
George J Vlay	San Francisco
James E Graf	San Gabriel Valley
Frank L Cole	Tucson
David W Hoeppner	Utah
James Caterson	International
Peter D Friar	International
Jean-Pierre Marec	International
Arthur W Rizzi	International
Gottfried P Sachs	International
Norio Yamaguchi Jr	International
Yutaka C Yamaguchi	International

In March, the Embry-Riddle AIAA Student Branch in Daytona Beach hosted AIAA Distinguished Lecturer Todd Barber. About 30 students attended Todd's lecture, "Lord of the Rings: Cassini Mission to Saturn," which was followed by an informal networking/question-and-answer period.

MENSAH INDUCTED INTO NATIONAL ACADEMY OF INVENTORS

AIAA Atlanta Section member and former Chair, **Dr. Thomas Mensah**, was inducted as a Fellow into the National Academy of Inventors (NAI) by the Deputy U.S. Commissioner for Patent Operations Andrew Faile and Dr. Paul Sanberg, NAI president, at the NAI Annual Conference at the California Institute of Technology on 20 March.

Dr. Mensah is the president and CEO of Georgia Aerospace Systems, an advanced aerospace composite manufacturing company in Atlanta, GA. He is a recognized authority on fiber optics and nanotechnology and holds over 25 issued and pending patents. An AIAA Associate fellow, he currently is the AIAA Region II Deputy Director for Technology.

Dr. Mensah with (left) Andrew Faile and (right) Dr. Paul R. Sanberg. (*Photo courtesy of National Academy of Inventors*)

In April, the AIAA Student Branch at the Illinois Institute of Technology welcomed AIAA Fellow Dr. John Tracy (center) to speak to members of the student branch and others. Dr. Tracy, who is the Chief Technology Officer and Senior Vice President of The Boeing Company, spoke about the aerospace industry and his engineering career. Branch members then presented their work from project teams for High-Altitude Student Payload (HASP) and UAVs. The event concluded with some informal chat and networking.

CALL FOR NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 October**.

Any AIAA member in good standing may serve as a nominator and are highly urged to carefully read award guidelines to view nominee eligibility, page limits, letters of endorsement, etc. Please note that the nomination form, related materials, and the three required AIAA member letters of endorsement must be submitted to AIAA by the nomination deadline.

AIAA members may submit nominations online after logging into www.aiaa.org with their user name and password. You will be guided step-by-step through the nomination entry. If preferred, a nominator may submit a nomination by completing the AIAA nomination form, which can be downloaded from www.aiaa.org. Nominators are reminded that the quality of information is most important.

Awards are presented annually, unless otherwise indicated. However AIAA accepts nomination on a daily basis and applies to the appropriate award year.

Premier Awards & Lectureships

Distinguished Service Award gives unique recognition to an individual member who has provided distinguished service to the Institute over a period of years.

Goddard Astronautics Award is the highest honor AIAA bestows for notable achievement in the field of astronautics. This award honors Robert H. Goddard—rocket visionary, pioneer, bold experimentalist, and superb engineer.

International Cooperation Award recognizes individuals who have made significant contributions to the initiation, organization, implementation, and/or management of activities with significant United States involvement that includes extensive international cooperative activities in space, aeronautics, or both.

Reed Aeronautics Award is the highest award AIAA bestows for notable achievement in the field of aeronautics. The award is named after Dr. Sylvanus A. Reed, the aeronautical engineer, designer, and founding member of the Institute of Aeronautical Sciences in 1932.

Dryden Lectureship in Research was named in honor of Dr. Hugh L. Dryden in 1967, succeeding the Research Award established in 1960. The lecture emphasizes the great importance of basic research to the advancement in aeronautics and astronautics and is a salute to research scientists and engineers.

von Kármán Lectureship in Astronautics honors Theodore von Kármán, world-famous authority on aerospace sciences. The award recognizes an individual who has performed notably and distinguished himself technically in the field of astronautics.

Technical Excellence Awards

Aeroacoustics Award is presented for an outstanding technical or scientific achievement resulting from an individual's contribution to the field of aircraft community noise reduction.

Aerodynamics Award is presented for meritorious achievement in the field of applied aerodynamics, recognizing notable contributions in the development, application, and evaluation of aerodynamic concepts and methods.

Aerodynamic Measurement Technology Award is presented for continued contributions and achievements toward the advancement of advanced aerodynamic flowfield and surface measurement techniques for research in flight and ground test applications. (Presented even years)

Aerospace Communications Award is presented for an outstanding contribution in the field of aerospace communications. Candidates are individuals or small teams (up to 4 members) whose achievements have had a positive impact on technology and society.

Aircraft Design Award is presented to a design engineer or team for the conception, definition, or development of an original concept leading to a significant advancement in aircraft design or design technology.

Chanute Flight Test Award recognizes significant lifetime achievements in the advancement of the art, science, and technology of flight test engineering. (Presented even years)

Engineer of the Year is presented to an individual member of AIAA who has made a recent significant contribution that is worthy of national recognition. Nominations should be submitted to your AIAA Regional Director.

F. E. Newbold V/STOL Award recognizes outstanding creative contributions to the advancement and realization of powered lift flight in one or more of the following areas: initiation, definition and/or management of key V/STOL programs; development of enabling technologies including critical methodology; program engineering and design; and/or other relevant related activities or combinations thereof that have advanced the science of powered lift flight. (Presented every 18 months)

Fluid Dynamics Award is presented for outstanding contributions to the understanding of the behavior of liquids and gases in motion as related to need in aeronautics and astronautics.

Ground Testing Award is presented for outstanding achievement in the development or effective utilization of technology, procedures, facilities, or modeling techniques or flight simulation, space simulation, propulsion testing, aerodynamic testing, or other ground testing associated with aeronautics and astronautics.

Hap Arnold Award for Excellence in Aeronautical Program Management is presented to an individual for outstanding contributions in the management of a significant aeronautical or aeronautical-related program or project.

Hypersonic Systems and Technologies Award recognizes sustained, outstanding contributions and achievements in the advancement of atmospheric, hypersonic flight and related technologies. (Presented every 18 months)

Jeffries Aerospace Medicine & Life Sciences Research Award is presented for outstanding research accomplishments in aerospace medicine and space life sciences.

Losey Atmospheric Sciences Award recognizes outstanding contributions to the atmospheric sciences as applied to the advancement of aeronautics and astronautics.

Multidisciplinary Design Optimization Award is presented to an individual for outstanding contributions to the development and/or application of techniques of multidisciplinary design optimization in the context of aerospace engineering. (Presented even years)

Otto C. Winzen Lifetime Achievement Award is presented for outstanding contributions and achievements in the advancement of free flight balloon systems or related technologies. (Presented odd years)

Piper General Aviation Award is presented for outstanding contributions leading to the advancement of general aviation. (Presented even years)

Plasmadynamics and Lasers Award is presented for outstanding contributions to the understanding of the physical properties and dynamical behavior of matter in the plasma state and lasers as related to need in aeronautics and astronautics.

Jay Hollingsworth Speas Airport Award is presented to the person or persons judged to have contributed most outstandingly during the recent past toward achieving compatible relationships between airports and/or heliports and adjacent environments. The award consists of a certificate and a $7,500 honorarium. Jointly sponsored by AIAA, the American Association of Airport Executives, and the Airport Consultants Council. (Nominations due **1 November**)

Theodor W. Knacke Aerodynamic Decelerator Systems Award recognizes significant contributions to the effectiveness and/or safety of aeronautical or aerospace systems through development or application of the art and science of aerodynamic decelerator technology. (Presented odd years)

Thermophysics Award is presented for an outstanding singular or sustained technical or scientific contribution by an individual in thermophysics, specifically as related to the study and application of the properties and mechanisms involved in thermal energy transfer and the study of environmental effects on such properties and mechanisms.

James Van Allen Space Environments Award recognizes outstanding contributions to space and planetary environment knowledge and interactions as applied to the advancement of aeronautics and astronautics. The award honors Prof. James A. Van Allen, an outstanding internationally recognized scientist, who is credited with the early discovery of the Earth's "Van Allen Radiation Belts." (Presented even years)

Service Award

Public Service Award honors a person outside the aerospace community who has shown consistent and visible support for national aviation and space goals.

For further information on AIAA's awards program, please contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7623.

OBITUARIES

AIAA Fellow Townsend Died in April

Marjorie R. Townsend, an electrical engineer who became the first woman to manage a U.S. spacecraft launch, died on 4 April. She was 85.

After enrolling in college at age 15, she became the first woman to receive an engineering degree from George Washington University in 1951. She then was a physical science aide at what is now the National Institute of Standards and Technology and worked on sonar-signal-processing mechanisms for anti-submarine warfare at the Naval Research Laboratory.

In 1959, Mrs. Townsend joined NASA, working at NASA Goddard Space Flight Center where she helped develop the first successful weather satellites, including TIROS-1 and the Nimbus satellite series. From the mid-1960s to 1975, she managed the agency's small astronomy satellite program, where she was responsible for the design, construction, testing, and orbital operations of NASA's first astronomical spacecraft. Most notably, she oversaw the development and launch of Uhuru, the world's first X-ray astronomy satellite, which was used to detect, survey, and map celestial X-ray sources and gamma-ray emissions. It was the first U.S. spacecraft to be launched by another country (Italy) in a foreign location (the coast of Kenya). The data collected from Uhuru helped revolutionize the field of high-energy astronomy and astrophysics.

Mrs. Townsend served as the program manager for NASA's applications explorer missions program before retiring in 1980. She received the agency's Exceptional Service Medal and Outstanding Leadership Medal. She was director of space systems engineering at BDM International and then vice president for space systems development for Space America until her second retirement in 1996.

Townsend was named a Knight of the Italian Republic Order in 1972 for her contributions to U.S.–Italian space efforts. She also was chair of a local chapter of AIAA, past president of the Washington Academy of Sciences, and a fellow of the Institute of Electrical and Electronics Engineers.

Associate Fellow North Died in April

Gilbert B. North died on 30 April 2015.

Mr. North earned his B.S. in Aerospace Engineering at Purdue University in 1947 and was a 1952 graduate of the U.S. Navy Test Pilot School. He served during World War II as an Army combat engineer and fighter pilot, and later with the Missouri Air National Guard, 110th Fighter Sq.

He retired from McDonnell Douglas in 1985 after a 38-year career; was an experimental pilot on the XF3H, XF-88, F2H, F3H, and F-101; and managed/flew test programs at Patuxent NAS, Glenview NAS, Kirtland AFB, and Edwards AFB. His engineering assignments included advanced design, the Mercury and Gemini programs, as well as the F-4, and F-15. On Mercury and Gemini at Cape Canaveral, Mr. North was the MDC engineering manager on propulsion, environmental, fuel cell, and cryogenics.

Senior Member Hoverman Died in May

William O. Hoverman died on 3 May 2015.

Building his own equipment, Mr. Hoverman was licensed as an amateur radio operator in 1941 and continued a lifetime pursuit of electronics and physics. He graduated from Brown University in 1947, and served as dispersing officer aboard the USS Spokane in the European theater. Following his discharge from the U.S. Navy, he held executive positions at General Electric Company, Northrop and Rockwell International, retiring in 1988. While with Rockwell, he was associated with the Space Shuttle Orbiter program in Downey and at Plant 42 in Palmdale.

An avid pilot, he was an instructor in gliders and accumulated 6000 hours flying time in single engine aircraft and gliders. He held the Amateur Radio call sign W6FW with honor for his activities. Memberships included AIAA, IEEE, AOPA, SSA, AVSC, and AVARC.

AIAA Member Rose Died in May

James T. Rose, an early pioneer of commercial pursuits in space, died on 24 May.

Mr. Rose's long career in aerospace began with a position as an aeronautical research engineer at Langley Research Center, developing satellites for the Vanguard program. Next, as one of the first Space Task Group members, he became a NASA project engineer on Project Mercury and in 1961, joined NASA's advanced manned space project, which was later named Gemini.

In 1964, Mr. Rose joined McDonnell Aircraft, Gemini's contractor, as systems control manager for guidance and control. He continued with McDonnell Douglas Corporation in positions of increasing responsibility until 1974, when he returned to government service under his mentor, John F. Yardley. From NASA Headquarters in Washington, DC, he directed vehicle development and engineering on the space shuttle program.

In 1976, Mr. Rose returned to McDonnell Douglas Astronautics Company in St. Louis as manager of space shuttle payload development for research and commercial applications of space. In that capacity, he applied his talent and skill toward utilizing the nation's space transportation system for commercial advancement. He created Electrophoresis Operations In Space (EOS), the first joint endeavor agreement between industry and NASA to bring space commercialization into reality. This program exploited the unique aspects of space microgravity to separate pharmaceuticals in space. McDonnell Douglas partnered with Ortho Pharmaceuticals on this far-reaching effort. EOS developed many firsts, including launching the first non-NASA shuttle passenger, McDonnell Douglas engineer Charles Walker, as a payload specialist. The program was dealt a significant setback by the loss of Space Shuttle Challenger in 1986. During the flight hiatus, other scientific advances eclipsed the advances of space-based manufacturing, bringing EOS to an end.

Undaunted, in 1987, after 20 years with industry, Jim accepted a government position as NASA assistant administrator for Commercial Programs. In that capacity he continued to promote many possibilities for the use of space to a wide variety of business interests. At its zenith, more than 200 U.S. corporations attracted to space and other commercial applications were affiliated with the 17 NASA Centers for the Commercial Development of Space (CCDS).

Mr. Rose retired from NASA in December 1991. He continued to consult internationally for several years early in his retirement. He received many honors throughout his career, including NASA's Distinguished Presidential Rank Award, the highest honor bestowed upon a government employee, and NASA's Exceptional Service Medal; the Aerospace Laurel Award; and AIAA's Lindbergh Award.

To submit articles to the *AIAA Bulletin*, contact your Section, Committee, Honors and Awards, Events, Precollege, or Student staff liaison. They will review and forward the information to the *AIAA Bulletin* Editor. See the AIAA Directory on page **B1** for contact information.

Upcoming AIAA Continuing Education Courses

Courses at AIAA Propulsion and Energy Forum 2015
www.aiaa-propulsionenergy.org/ContinuingEd

25–26 July 2015

The Application of Green Propulsion for Future Space (Instructors: Alan Frankel and Timothee Pourpoint)
Liquid propulsion systems are critical to launch vehicle and spacecraft performance and mission success. This two-day course, taught by a team of government, industry, and international experts, will cover propulsion fundamentals and topics of interest in launch vehicle and spacecraft propulsion, non-toxic propulsion drivers, propellants and figures of merit, applications of non-toxic propulsion, flight experience, and advances in smallsat propulsion. Lessons learned from development and flight of components and systems will be discussed.

Key Topics
- History of Hydrazine/Hypergols
- What is Green and what drives Green movement
- Green Propellants
- Flight and Near Term Flight Experience
- Applications of Green – What drives propulsion decisions
- Challenges for Green Propulsion

Advanced High Speed Air-Breathing Propulsion (Instructors: Tomasz Drozda, Doug Garrard, Bob Moehlenkamp, Dora E. Musielak, Steve Russell, Venkat Tangirala)
Revolutionary methods of high speed air-breathing propulsion are needed to extend the flight regime of aircraft, missiles, and improve Earth-to-orbit spacecraft. Advanced High Speed Air-Breathing Propulsion will introduce students to the design and development processes of high speed propulsion, including ramjet/scramjets and TBCC concepts. The course will present a comprehensive overview of the state of the art, including highlights of current high speed propulsion programs in the world. An introduction to multidisciplinary design optimization (MDO) will help students appreciate the challenges of developing this breakthrough propulsion technology.

The instructors are actively engaged in high-speed propulsion R&D. They will discuss the challenges, and development trends and future of the propulsion technologies needed to make truly high speed flight a reality. This course is sponsored by the AIAA High Speed Air Breathing Propulsion Technical Committee (HSABP TC).

Key Topics
- Mission requirements
- Combined cycle propulsion concepts
- Ramjet/scramjet inlet design
- Ram/scramjet combustion structural design
- Fuels and thermal management engine/airframe integration, TBCC integration
- Advanced materials
- CFD modeling and simulation of high speed reacting flow
- Propulsion multidisciplinary design optimization (MDO)
- High speed propulsion ground and flight testing

30–31 July 2015

Business Management for Engineers (Instructors: Alan C. Tribble and Alan Breitbart)
This course will help individuals with a technical background master the business principles that guide the leadership of an engineering-oriented company. The course will prepare students for the transition from the role of a technical contributor to that of a business leader.

Key Topics
- Basic principles—Economics and free markets
- Project execution—Technical performance measures and earned value management
- Business management—Business finance concepts used to evaluate a product or business
- Developing and presenting a business case—Articulating a value proposition and presenting a business message
- Initiating and planning a program—Understanding what needs to be managed and how to manage it
- Business development—Growing an idea into a business
- Globalization—Navigating import/export regulations and expanding internationally

Hybrid Rocket Propulsion (Instructor: Dr. Joe Majdalani)
This course reviews the fundamentals of hybrid rocket propulsion with special emphasis on application-based design and system integration, propellant selection, flow field and regression rate modeling, solid fuel pyrolysis, scaling effects, transient behavior, and combustion instability. Advantages and disadvantages of both conventional and unconventional vortex hybrid configurations are examined and discussed.

Key Topics
- Introduction, classification, challenges, and advantages of hybrids
- Similarity and scaling effects in hybrid rocket motors

- Flowfield modeling of classical and non-classical hybrid rockets
- Solid fuel pyrolysis phenomena and regression rate: Mechanisms & measurement techniques
- Combustion instability and transient behavior in hybrid rocket motors
- Metals, other energetic additives, and special binders used in solid fuels for hybrid rocket applications

Courses at AIAA Space and Astronautics Forum 2015 (AIAA SPACE 2015)
www.aiaa-space.org/ContinuingEd

29–30 August 2015

Introduction to Space Systems (Instructor: Dr. Mike Gruntman)

This course provides a broad overview of the concepts and technologies of modern space systems that combine engineering, science, and external phenomena. We concentrate on scientific and engineering foundations of spacecraft systems and interactions among various satellite subsystems. These fundamentals form an indispensable basis for system engineering. The basic nomenclature, vocabulary, and concepts will make it possible to interact with understanding with various subsystem specialists.

Key Topics

- Space environment and interactions
- Orbital mechanics and space mission geometry
- Overview of space mission design and applications
- Space propulsion and launch systems
- Attitude determination and control
- Communications, power, and thermal control subsystems

Technical Committee Nominations

Membership nominations are now open for AIAA Technical Committees (TC) for 2016/2017. Our TCs have between 30 and 35 members each. Nearly one-third of the members rotate off the committees each year, leaving six to ten openings per TC.

The TC chairs and the Technical Activities Committee (TAC) work diligently to maintain a reasonable balance in (1) appropriate representation to the field from industry, research, education, and government; (2) the specialties covered in the specific TC scopes; and (3) geographical distribution relative to the area's technical activity. TAC encourages the nomination of young professionals, and has instituted a TC associate member category (see associate membership guidelines). Associate members, with identified restrictions, are included on TCs in addition to the 35 regular member limit.

If you currently serve on a TC, do not nominate yourself. You will automatically be considered for the 2016/2017 TC year.

Enclosed are instructions for nominations. Nominations are submitted online. The TC nomination form can be found on the AIAA Web site at **www.aiaa.org**, under My AIAA, Nominations and Voting, Technical Committee Online Nomination. We look forward to receiving your nominations. If you have any questions, please call Betty Guillie at 703.264.7573.

Nominations are due by **1 November 2015**.

Current AIAA Technical Committees

Adaptive Structures

Aeroacoustics

Aerodynamic Decelerator Systems

Aerodynamic Measurement Technology

Aerospace Power Systems

Air Breathing Propulsion Systems Integration

Air Transportation Systems

Aircraft Design

Aircraft Operations

Applied Aerodynamics

Astrodynamics

Atmospheric and Space Environments

Atmospheric Flight Mechanics

Balloon Systems

Communications Systems

Computer Systems

Design Engineering

Digital Avionics

Economics

Electric Propulsion

Energetic Components and Systems

Flight Testing

Fluid Dynamics

Gas Turbine Engines

General Aviation

Ground Testing

Guidance, Navigation and Control

High Speed Air Breathing Propulsion

History

Hybrid Rockets

Information and Command and Control Systems

Intelligent Systems

Legal Aspects of Aeronautics and Astonautics

Life Sciences and Systems

Lighter-Than-Air Systems

Liquid Propulsion

Management

Materials

Meshing, Visualization and Computational Environments

Microgravity and Space Processes

Missile Systems

Modeling and Simulation

Multidisciplinary Design Optimization

Non-Deterministic Approaches

Nuclear and Future Flight Propulsion

Plasmadynamics and Lasers

Product Support

Propellants and Combustion

Sensor Systems and Information Fusion

Small Satellite

Society and Aerospace Technology

Software

Solid Rockets

Space Architecture

Space Automation and Robotics

Space Colonization

Space Logistics

Space Operations and Support

Space Resources

Space Systems

Space Tethers

Space Transportation

Spacecraft Structures

Structural Dynamics

Structures

Survivability

Systems Engineering

Terrestrial Energy Systems

Thermophysics

V/STOL Aircraft Systems

Weapon System Effectiveness

Instructions for Completing Technical Committee Nomination Forms

1. Nominations are submitted online via www.aiaa.org, My AIAA, Nominations and Voting, Technical Committee Online Nomination. Nominees who are not selected for committee membership for 2016 will automatically be considered for membership in 2017. As the nomination forms are held for an additional year, it is not necessary to resubmit a form for someone not selected for the 2015/2016 term. You may send updated information to be attached to an existing nomination form.
2. You do not have to be nominated by someone else; you may submit an application for yourself.
3. A resume or biographical data can be uploaded with the online nomination form.
4. Membership is usually restricted to one technical committee (TC) at a time. Please list the TCs in order of preference if applying to two TCs. If accepted to the 1st priority, the nominee will be added to that TC. All information should be detailed and complete.
5. The Technical Activities Committee (TAC) strongly suggests that special consideration be given to members 34 years of age and under or who obtained their professional degree less than 10 years ago. See attached Technical Committee Associate Membership Guidelines.
6. All TC members must join AIAA (if they are not already members) within 45 days of their appointment to a technical committee.
7. TC membership is generally for one year with two additional years possible, but contingent upon committee participation, ongoing projects, and AIAA membership. It is not necessary to send a new nomination form for someone who is already on a committee. All committee members are automatically considered for a second and third year of membership.
8. Deadline for receipt of nominations is **1 November 2015**. Nominations received after this date will be held for consideration until the next year.

Technical Committee Associate Membership Guidelines

1. Associate membership is restricted to those who have not yet reached their 35th birthday, or who obtained their professional degrees less than 10 years ago.
2. Associate membership is a one-year term renewable to three years.
3. Associate membership is restricted to current AIAA members.
4. Selection to associate membership is based on technical merit. The associate members should show promise within the field of the technical committee.
5. Associate members may attend TC or subcommittee meetings and will assist in carrying out committee work.
6. At the discretion of the TC, associate members may be assigned a volunteer full member as a counselor. The counselor will advise and guide the associate member on TC procedures and activities.
7. Associate members will not count toward the TC regular membership limit.
8. Application forms for associate membership are the same as those of full membership, but a resume is a required attachment. Applicants for full membership who were not selected may be considered associate members provided they meet the age restriction.
9. At least two associate members should be appointed to each TC. At no time should the number of associate members exceed that of full members.
10. An endorsement statement from the nominee's department head, indicating that the nominee may travel to two meetings per year and have some time to devote to committee business, must be completed during the online process.

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- Work/Life Balance Challenges for the 21st Century
- The Media and the Engineering Profession

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