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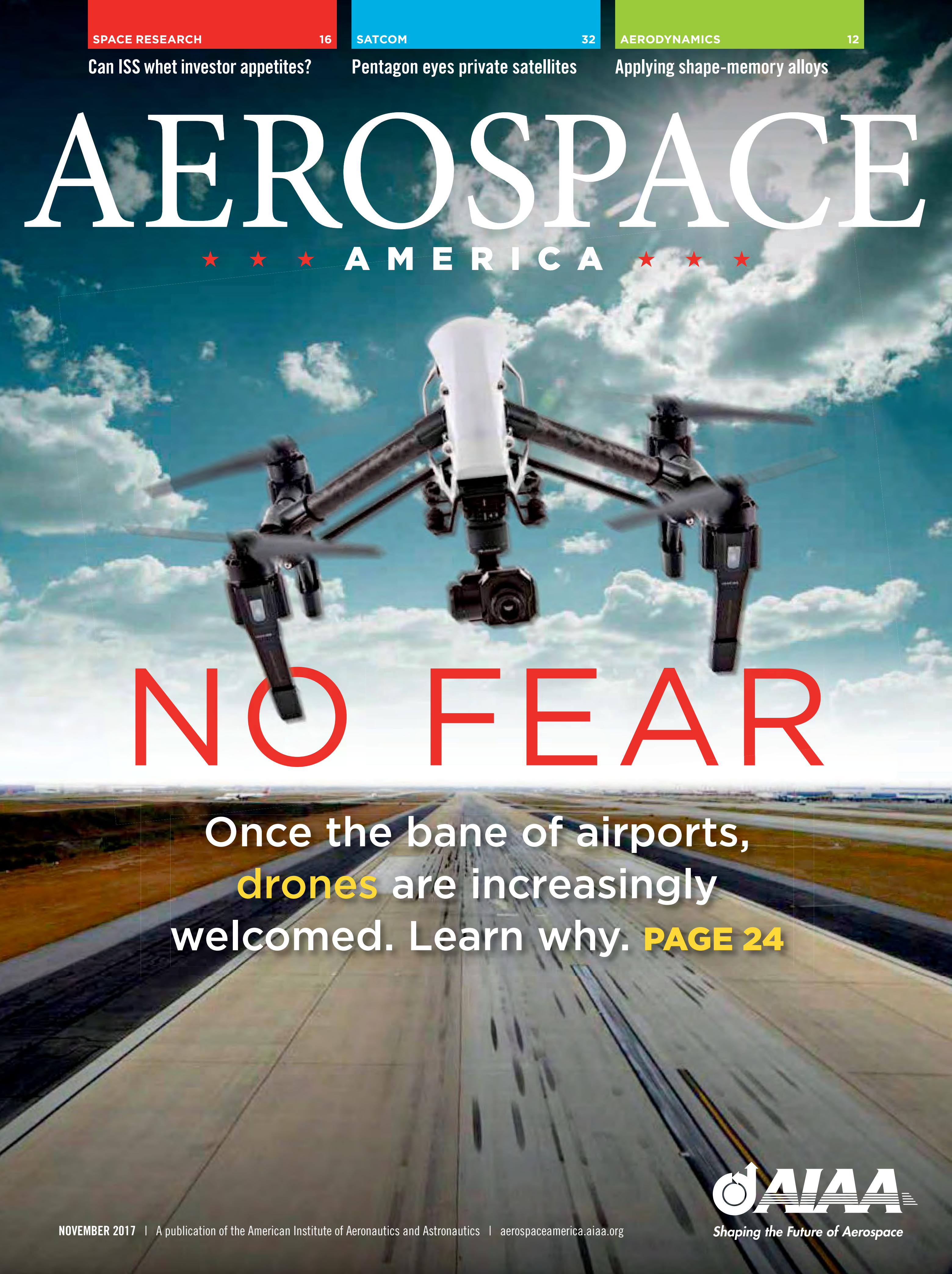

NO FEAR

Once the bane of airports, drones are increasingly welcomed. Learn why. PAGE 24

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On the cover: Photo illustration of a drone superimposed on a runway at Hartsfield-Jackson Atlanta International Airport.

Image credit: Michael Baker International, Canard Drones

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AEROSPACE AMERICA

NOVEMBER 2017, VOL. 55, NO. 10

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IN THIS ISSUE

Keith Button

Keith has written for C4ISR Journal and Hedge Fund Alert, where he broke news of the 2007 Bear Stearns scandal that kicked off the global credit crisis.

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Adam Hadhazy

Adam reports on astrophysics and technology. His work has appeared in Discover and New Scientist magazines.

PAGE 16

Joe Stumpe

A freelance reporter based in Wichita, Kansas, Joe has written for The New York Times, Agence France-Presse and The Huffington Post.

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Debra Werner

A frequent contributor to Aerospace America, Debra is also a West Coast correspondent for Space News.

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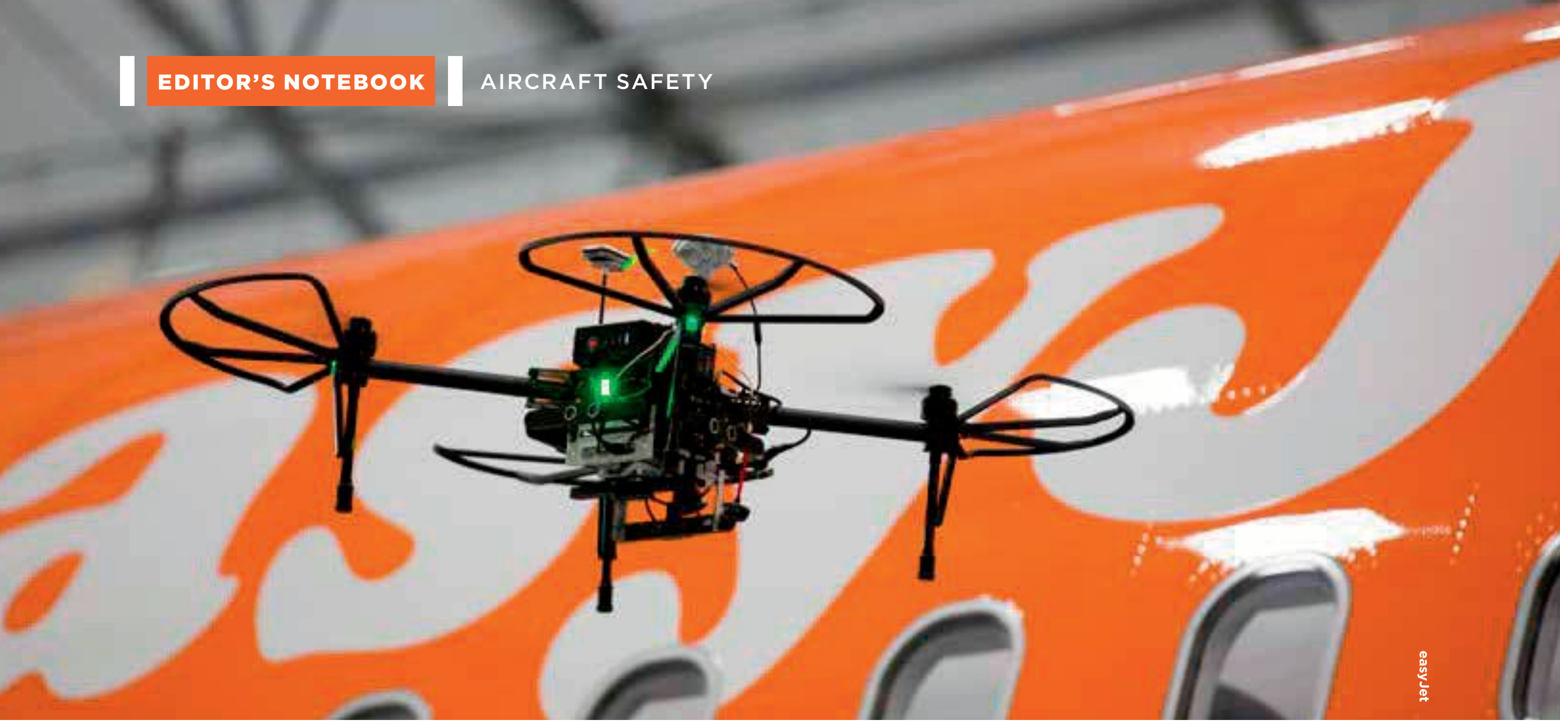
DEPARTMENTS



easyJet

Aviation made easy

▲ **EasyJet is testing** an inspection drone to detect damage on its airliners from lightning strikes and other hazards.

This month's issue reminds me how difficult it is to prognosticate wisely about the future of aviation. Assessing whether an idea is technically feasible is probably the easy part, but even then, emotion can temporarily cloud one's judgment. Two years after the famous first flight, Wilbur Wright reportedly confessed that in 1901 he told Orville that "man would not fly for 50 years."

Technologists pride themselves on following data and reason, and more times than not, that culture prevails. Wilbur and Orville did not give up.

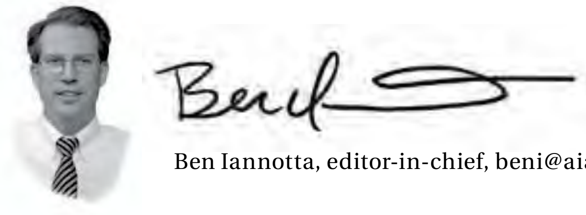
Far trickier is to predict or motivate a specific consumer behavior, especially when safety and dollars are involved.

Will transportation consumers someday accept a fully automated aircraft without a human pilot aboard? The answer won't "depend on the regulators, it's going to depend on public perception," says air safety advocate Mary Schiavo in this month's Q & A on Page 10.

Safety will be part of that perception, but it's not the whole story. Richard Thaler, the 2017 winner of the Nobel Prize in economic sciences, has long said that if you want to motivate someone to act, you need to "make it easy" to do so. We've probably all seen firsthand what he means. Some years ago, when my beat was military intelligence, an officer at the annual Geospatial Intelligence symposium told a roomful of technologists that their computers and software often sat in unopened boxes. Troops didn't have time to figure them out. They preferred their intuitively designed smartphones.

One can see that kind of intuitive ease-of-use in the small drone market. As our cover story points out, not that long ago, the thought of 1.1 million small drones in the hands of consumers sparked nothing but fear in the air travel industry. What if a drone got away from its operator and was sucked in by an airliner's engine? Safety remains a valid concern, but it's no longer the whole story. Today, drones have safety features and an ease of use that make them attractive for professionals who need to inspect runways or passenger jets in their hangars.

Drone designers have made it easier for hobbyists and professionals alike. That's a good lesson for nearly any field. ★



Ben Iannotta, editor-in-chief, beni@aiaa.org

Missing ingredient in deep space plan

An agreement in principle was signed between NASA and Roscosmos (the Russian Space agency) on Sept. 27, 2017 in Adelaide, Australia. The two major space agencies made a commitment to cooperate within the framework of an international level to set up the Deep Space Gateway, standardize equipment and techniques, and act in the continuity of the current exchanges on the International Space Station. The Russians will bring their know-how in particular regarding interfaces of mooring and inhabited airlocks, and will study the possibility of using Russian launchers such as Proton and future Angara A5.

However, there was still no signing of an international agreement such as that of Jan. 29, 1998, for ISS. The real signal will be the allowance of budgets for construction of first elements of the DSG.

The European Space Agency, or ESA, invited members of the scientific community in Europe to propose ideas for the research that could be made aboard the DSG. ESA will indeed hold a workshop on this matter at the European Space Research and Technology Center in Noordwijk, Netherlands, in December 2017. More information is available here: http://exploration.esa.int/moon/59376-call-for-ideas/ ★

Philippe A. Mairet
Toulouse, France
AIAA senior member

NASA

▲ In an artist's rendering, the European Space Agency's service module is beneath NASA's Orion spacecraft. ESA describes the mission as a "vision" that will help to build a Deep Space Gateway.

News from Intelligent Light

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Seth Lawrence, Applied Research Group (ARG), recently presented his research on Uncertainty Quantification (UQ) at the ASME V&V symposium that combined CFD and UQ analysis (ASME VVS2017-4033).

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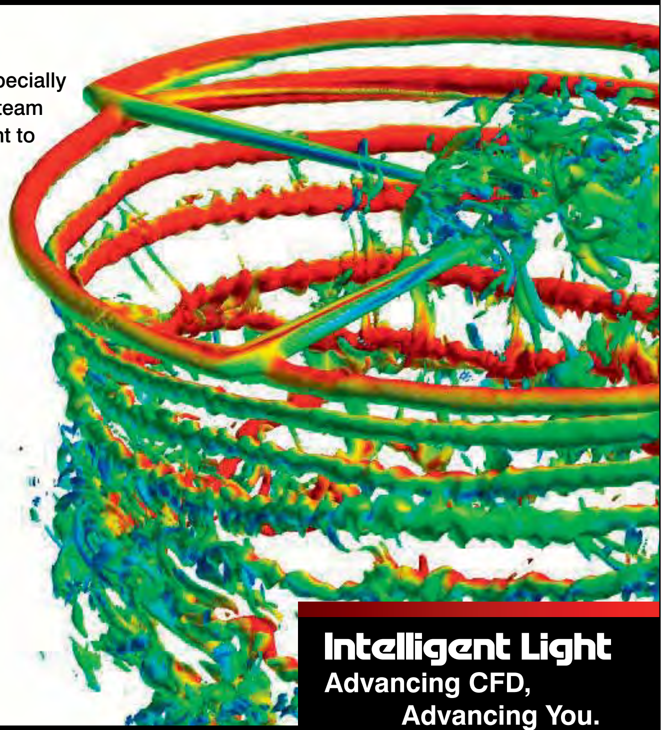

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FieldView image courtesy of Prof. James G. Coder, University of Tennessee, Knoxville

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FROM THE CORNER OFFICE

AIAA Engage: AIAA's New Online Community Platform

It is an exciting time at AIAA. The Institute is becoming more agile, better able to respond to new ways of communicating and collaborating. One of the ways we are doing so is by introducing a comprehensive online community system—**AIAA Engage**—from a company called Higher Logic. It is currently in beta testing, but I am excited by the potential of this new platform, and want to give you a sneak peek before its official debut in January.

We all know the value of teamwork and understand the practical benefits of having a collaborative space for information sharing, idea exchange and discussion. To date this has been accomplished via AIAA forums, events, publications, and email. But many of you have told us that you want a better "virtual" way to connect, more than static online committee listings and calendars of upcoming events. And so, after much research, we are introducing AIAA Engage—to further improve your member experience.

What is it?

If you are familiar with Reddit, LinkedIn bulletin boards, or chat rooms, you understand the idea of online communities. AIAA Engage will be our moderated, limited-access version with similar discussion formats to these other platforms—but with far more robust functionality, and focused specifically on the global aerospace community.

What can you do with it?

Of course, we will use it to manage the basic, yet important, administrative tasks surrounding existing committees and sections such as maintaining files and rosters, but the exciting part concerns what the platform will do beyond that.

- Share individual member profiles with as much—or as little—as members like about themselves and their work.
- Establish a feature "Ask Me Anything" consisting of online Q/A sessions with forum speakers, notable authors, and other experts in the field.
- Host continuing education seminars and have follow-up discussions based on what members are learning.
- Highlight breaking news items, linking photos, videos, and files.
- Host discussions of the latest research coming out of the forums as specific as a certain paper, or as broad as a new vision.
- Allow collaboration on design competitions and sharing of those experiences.
- Enable connection between job seekers, mentors, and mentees.
- Allow for search and connect with other members based on location, alma mater, or employer.

When is it happening?

Our phased rollout started a few months ago with selective, but representative, test groups: a technical committee, young professional committee, and our section leadership. We all learned how to use the platform as we went, improving our processes along the way.

We also stood up a new Community of Interest (CoI) that had emerged organically from conversations based on the programming at the 2017 AIAA AVIATION Forum. AIAA Fellow Rich Wahls and a dozen others agreed to test the Higher Logic platform as a collaboration tool. Their working group is exploring the safe efficiencies that may be captured if aircraft certification moves from ground testing to adaptive modeling. The members of this group span a wide range of technical disciplines and perspectives. This collaboration would have been difficult to fit into our previous organizational configuration, so it is exciting to think that their work is being supported by AIAA Engage. For the first time, we have been able to provide a platform for interest groups within a matter of months, rather than years. As Rich Wahls said himself, *"This is the beginning of something big. I feel it."*

It is indeed just the beginning. We anticipate launching the platform to our full membership in January after the 2018 AIAA SciTech Forum.

What does it mean?

We envision that AIAA Engage will become the place where our community comes to collaborate and connect. We will explore the new frontiers of innovation and find the connections that will catapult us into the future. Members will have control about what information is shared and frequency of engagement. For those already familiar with social media the learning curve will be gentle.

We are excited about the potential of this platform, and we invite all AIAA members to Engage with us and with each other.

Details to follow. ★

Sandra H. Magnus, AIAA Executive Director

Stratolaunch

The team building the Stratolaunch tested its six Pratt & Whitney engines in September at the company's Mojave, California, site.

HyperSizing the largest aircraft

BY HENRY CANADAY | htcanaday@aol.com

Stratolaunch Systems Corp.

A HyperSizer analysis of part of the all-composite Stratolaunch was displayed on a computer screen while one of the aircraft's two fuselages (below) was under construction.

The designers of Stratolaunch faced a daunting task six years ago when they set out to conceive an aircraft that could fly to the stratosphere and release a reusable rocket that would blast into orbit payloads weighing up to a combined 250,000 kilograms. They needed to ensure that the design of the plane's massive wings and fuselage weighed no more than necessary to meet safety and manufacturing requirements.

They'll soon find out whether any adjustments might be required. Stratolaunch Systems, based in Seattle and backed by Microsoft co-founder Paul Allen and Scaled Composites founder Burt Rutan, is ground-testing the plane's six Pratt & Whitney PW4000 engines in anticipation of a first flight over Mojave, California, in a few months, followed by a first space launch planned for 2019.

Mojave-based Scaled Composites, which is building Stratolaunch, began using Collier Research Corp.'s HyperSizer design software at the start of design in 2011. Craig Collier led the NASA team that developed HyperSizer starting in 1988. The software was commercialized in 1995. Scaled Composites licensed the software, and its stress-team engineers used it. Government and industry engineers have applied it to some big-name projects, including the design of NASA's now-defunct Ares 5 rocket, the heat shield of the Orion crew module and the Spirit Aero/Bell Helicopter V280. Now president of Collier Research in Virginia, Collier says the software typically reduces weight of structures by 20 to 40 percent from designs done without HyperSizer.

"As flight testing begins and small improvements to the airframe are made, HyperSizer will continue to be used," Collier says.

Stratolaunch was a distinctive challenge partly because its 117-meter wingspan made it the biggest airframe HyperSizer has been applied to, Collier says. The magnitude of loading resulted in thick laminates and a high count of plies, says Collier. "For the massive Stratolaunch wing, deflection limits were a significant factor to be taken into account," he adds. Deflection limit is the maximum degree a wing can be bent without risking failure. No other aircraft has ever reached even 100 meters in wingspan.

Scaled Composites' stress team consulted HyperSizer's comprehensive set of automated failure analyses that included rapid free-body analysis and discrete laminate sizing.

While having convenient features such as the ability to upload data from Excel software, the core of HyperSizer's approach is Finite Element Analysis. The software simulates the behavior of engineering structures and components under a variety of conditions to demonstrate stress, strain, the influence of temperature and pressure, and other factors.

Collier says that HyperSizer applies the same analytical methods in optimization that are used for final certification. "This produces optimum designs that do not have to change later as design matures from preliminary to final. And it allows analysis certification reports to be generated at any time during design." ★

Russia and U.S.: Uneasy space partners

BY TOM RISEN | tomr@aiaa.org

The U.S. and Russia plan to continue their dance of cooperation and competition in space, judging by Vice President Mike Pence's speech to the reconstituted National Space Council and interviews I've conducted over the months with officials from Roscosmos, NASA and U.S. Air Force Space Command.

Pence in October charged the National Space Council with "bringing the full force of our national interest to bear" to brainstorm how the U.S. can send humans on missions to the moon and Mars while asserting space dominance against Russia. His opening remarks at the council meeting came a week after Russia and the U.S. issued a joint statement in Australia pledging to collaborate on deep space exploration.

In their joint statement, Roscosmos and NASA made reference to NASA's conceptual Deep Space Gateway in lunar orbit, but they did not lay out a timeline for its construction or define what roles Russia and the U.S. would play. In NASA's concept, the gateway would be launched in several pieces for assembly in lunar orbit. Crews would arrive in Orion capsules and stay for up to 42 days to hone techniques and innovations for the trip to Mars. Eventually, NASA would launch a Deep Space Transport spacecraft to dock with the gateway and pick up a crew that would travel to Mars orbit.

Roscosmos Director General Igor Komorov told me during the Paris Air Show in June that his agency had already begun discussions with NASA about developing the station together in lunar orbit. Roscosmos said in its press release announcing the collaboration with NASA that the creation of the lunar station will begin in the mid-2020s. Both agencies promised a shared goal to make international cooperation in space easier by creating spacecraft with similar technical criteria, and announced they have already agreed on a common docking standard for the future station.

Komorov told me that reusable rockets being designed by SpaceX and Blue Origin, which aspire toward their own human exploration missions, could increase the affordability and frequency of launches needed to build a space economy. The Russian space director said his agency is working to meet the demands of this increasingly competitive market by addressing concerns about the reliability of its Proton and Soyuz rockets.

"For us it is a very strong request to improve the efficiency, to stabilize the quality of the launches, and a challenge for us to force us to make faster, new launchers," Komorov says.

In one view, American astronauts paying for rides into orbit on Russian rockets could amount to a partnership. Pence in his speech opening the space council termed that "capitulation." Pence said the U.S. pays Russia $76 million to ferry each astronaut to the International Space Station and said NASA must find another way to maintain a constant human presence in low Earth orbit.

"America must be as dominant in space as we are here on Earth," he said.

Cosmonauts and astronauts work together well in space, but tensions between their nations could complicate their partnership. Intelligence reports cited by Pence warn that Russia and China are pursuing technology and military strategy that could destroy, disable or spy on U.S. satellites.

Komorov during our interview shrugged off suspicions that Russian satellites maneuvering in Earth orbit — sometimes without explanation — could be testing sabotage or spying features.

"We do not break any rules or regulations [with] our satellites in space," he said with help from a translator. ★

NASA/GCTC/Irina Peshkova

▲ Cosmonauts and NASA astronauts often praise cooperation in space despite political tensions. Above, Expedition 53 flight engineer Joe Acaba of NASA, left, Soyuz commander Alexander Misurkin of Roscosmos, center, and Mark Vande Hei of NASA pose in September ahead of their launch to the International Space Station on a Soyuz rocket.

Courtesy of Mary Schiavo

Champion for aviation safety

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The same day that TWA Flight 800 exploded and crashed minutes after taking off from New York in 1996, Mary Schiavo, who had just left her post as the Transportation Department's inspector general, happened to be testifying on Capitol Hill about airline security. After the hearing, ABC News whisked her to its Washington bureau to discuss the breaking news, beginning her post-government career as a transportation attorney sought after for TV news, court cases and policy discussions. Schiavo has flown as a general aviation pilot and at one time wanted to be a commercial pilot, but the corrective lenses she wears eliminated that possibility. That eyesight policy has since changed, but Schiavo has no regrets about pursuing law and feels at home flying a plane or parachuting. I spoke with her about air safety regulation and technology on the phone from her Motley Rice law office in New York.
— *Tom Risen*

MARY SCHIAVO

POSITION: Transportation practice group head at Motley Rice law firm; CNN transportation analyst

RESIDES: Charleston, South Carolina

NOTABLE: Spent 15 years as a federal prosecutor with the Justice Department and as inspector general of the Department of Transportation; investigated sales of unapproved aircraft parts; scrutinized FAA oversight of ValuJet after a 1996 crash in the Everglades that killed all 110 aboard.

EDUCATION: Law degree from New York University. Master's degree in public administration from Ohio State University. Bachelor of Arts from Harvard University.

FAVORITE QUOTE: "The past is like a foreign country — you can visit but you don't live there."

IN HER WORDS

Common threads among aircraft crashes

In about three quarters of the cases, the NTSB and the FAA say that it is pilot error. From time to time in our investigations we've disagreed with NTSB. Often it's loss of situational awareness, loss of pilot control. Statistically after that you have engine problems. It used to be that weather was right up there as well, but the onboard radar has gotten so good. Weather is a contributing factor. Sometimes we still have icing issues although they're decreasing. Engine, tail, wing icing on smaller planes. We still sadly see controlled flight into terrain — like they flew into a mountain — and midairs, runway incursions. Those are the things that technology was supposed to have obliterated by now.

When technology is to blame

The old adage [is] that an air crash is never one thing, it is always a combination of things. About 20 percent of the time we see an engine issue. Engines can still be improved. Redundancy is a pilot's friend. Other than things like an engine failure, I mostly see a failure of maintenance. I worked on the Alaska 261 flight where the jack screw wasn't greased. More recently you see issues between the pilot and the equipment. They haven't paid attention to the warnings in the cockpit and so it's the interface of the human and the technology. Like Air France [Flight 447 and] Colgan Air [Flight 3407]. Now remember, I don't get on the litigation side. You might have a lot more engine problems, and issues, and glitches, and smoke in the cabin, and fumes in the cabin, and fumes and smoke in the cockpit from an engine issue, etc., but unless it takes a turn for the worse and someone gets hurt, then I don't work on the case.

Weather radar to prevent turbulence injury

It would go a really long way to help it, but of course, passengers have to keep the seat belts on. There's always somebody who doesn't get the message when the pilot says, "Sit down. Put your belt on." Weather most often [is a problem] when a pilot has tried to beat it, go through it, ignore it, or hasn't really checked. If you utter the words "I think we can make it," then you should have to do a mandatory diversion. I would say weather is also prevalent in about 20 percent of [crash] cases, but it's getting to the point where it's not by itself anymore.

Flight tracking ADS-B antennas

It would make an even bigger difference if everyone had it, and the full NextGen system was operational. It has the potential to make incursions and midair [collisions] a thing of the past. Now, I know, there's the big debate about how much equipment do we want to require in all of the aircraft. But absolutely, it's very important. We'll never take the humans out of the system, but I think artificial intelligence is how we're going to keep track of all our flights.

United Nations' response to MH370 disappearance

The U.N.'s International Civil Aviation Organization has asked, has begged the nations of the world to require the airlines to have real-time, ocean-spanning, around-the-globe tracking, but the sad part of that is I'm not sure any nation — I know ours hasn't — no one has made it mandatory. I can't fault ICAO because they don't have the power to say, "all planes must all be tracked at all times." It should be the governments of the world that say, "This will not happen again." ICAO had several conferences and they've put out guidelines and recommendations. I think they have done what they can. In the case of the MH370 disappearance, their protocol for how you do an investigation was very important because without it I don't think we would have gotten much of an investigation at all.

Why black boxes are still used

The regulatory agencies of the world haven't required change; until they require change no operator is going to voluntarily spend the money to change the system over to streaming software. There is no reason to have these worldwide searches for black boxes. The regulatory bodies in some ways are holding back the technological advancement. If they said, "We're not going to rely on searching for pings and black boxes in the mountains [or] under the ocean anymore," it would be done, and they would pass the cost on to the passengers.

Limited FAA privatization

I think air traffic control is inevitably privatized. Government isn't cutting-edge and responsive enough to really keep a system like that built out. But not necessarily as just one body. Eurocontrol and Nav Canada have a governing body of appointed officials, usually of significant standing in the nation or the community, and they oversee it so the needs of the citizens and the needs of the country aren't dismissed from the system. It's not a corporation only beholden to shareholders; it is a corporation that has to be responsive.

Safety of vertical takeoff craft/air taxis

There's a lot of companies building these potential air taxi vehicles, and they're wonderful, but has the FAA really looked at the quality of them? No. Both the developers and the potential regulators have their hands full because so many of them are relying on batteries. You've got the issue of the flight time. You've got the issue of safety — they're intending to operate in very close proximity of humans. You're going to have to protect the people from doing things that people tend to do, which is avoid safety. They ignore safety lines, and barriers, and so you're going to have to make it idiot-proof. The most logical thing is you're going to have a whole new system of regulation because this doesn't fit in part 121 [the FAA requirements for air carriers].

Fully automated flights

It's without a doubt that aviation can be made safe pilotless. The question is: Will the public accept it? If they have a safety record like commercial airliners or your car, people are going to do it. It's not going to depend on the regulators, it's going to depend on public perception.

FAA drone rules

They're too little too late. And so many of the rules are aimed at the silly stuff like how people are afraid that somebody's going to fly a drone over the backyard and see them sunbathing in the buff. I would be more worried about building a system that can safely allow those to fly without risk of collision ever, which means it's going to be entirely computer controlled. They've got to have absolutely fail-safe geofencing, and emergency go-home and landing capabilities. ★

Magic material

If the shape of a plane's wings could be adjusted in flight with small tubes made of a flexible alloy rather than with heavy mechanisms, the result would be better control and fuel economy. Keith Button spoke to a team of NASA and Boeing engineers that aims to do exactly that by mixing up an alloy that changes shape at specific temperatures.

BY KEITH BUTTON | buttonkeith@gmail.com

Othmane Benafan, a materials engineer at NASA's Glenn Research Center in Ohio, loves talking about nickel-titanium-hafnium, a chrome-looking alloy with a bright future. He speaks of its "memory" and about "training" it, almost as if this alloy were alive. Picture a tube made of it, he says. "You heat and cool it and this tube starts twisting," he says. "I work in this field, and it still amazes me every time I see it."

NiTiHf is among a class of shape-memory alloys, SMAs, that materials engineers like Benafan think could give aircraft designers a slew of bold new options. Training is achieved by bending the tubes to specific angles under force, then heating and cooling them to train them to return to that angle at a specific temperature.

Benafan is co-principal investigator for the Spanwise Adaptive Wing project at Glenn. Engineers from NASA and Boeing are teaching NiTiHf a new trick: To fold aircraft wingtips or sections of wings up and down in flight. If subscale flights and lab tests show promise in the coming months, airliners and fighter jets could someday adjust their wings for maximum fuel efficiency and control without bulky hydraulics, pneumatics or electric motors.

Subscale airliner

For the airliner application, the Spanwise team needed a subscale airliner with wings that could be removed and replaced with articulating versions that fold at the wingtips. They chose an 11 percent scale version of a Boeing 737, called PTERA, short for Prototype Technology Evaluation and Research Aircraft. This unmanned aircraft was built by Area I, a small company in Kennesaw, Georgia. The engineers cut each composite wing about 30 centimeters from the tip and reattached the wingtips, connected to the root wing by a single NiTiHf tube or actuator.

Now, newer passenger planes fly with fixed, upward-bent wingtips, called winglets, which reduce drag and save fuel. But adding wingtips that could fold up or down to specific angles could maximize yaw control or lift for their planes during specific flight phases, such as takeoff, landing, climb-out, descent and cruise, says Matthew Moholt, NASA's principal investigator on the Spanwise project. Designers could reduce or even eliminate tail rudders and their drag from new plane designs. Computer simulations show the PTERA enjoying increased yaw control or stability by folding the wings to specific angles in flight, and flight testing should prove that the simulations are correct, Moholt says.

An obvious challenge was that each tube had to bend only when desired. Under a previous NASA project, called Adaptive Trailing Edge, Boeing engineers had shown that SMA actuators could push the flaps up and down on the wings of a full-scale 737 in flight. That project was a breakthrough in that it was the first time an SMA moved a flight control surface in flight, but there was also a problem. The nickel-titanium mixture chosen for that project could start changing shape on an extremely hot day, when it wasn't supposed to. The Spanwise team chose nickel-titanium-hafnium, believing they could formulate it to change shape only at higher-than-natural-environment temperatures. The material had a relatively long research history to draw from. The first NiTiHf material was patented in 1992; NASA started working with versions of the alloy 12 years ago. Today, NASA engineers are patenting their own new NiTiHf alloys.

The Spanwise team needed to tune the specific actuation temperatures of the nickel-titanium-hafnium alloy, says Benafan. They wanted to set the "cold" temperature — when the SMA tube would return to its original shape — at 100 degrees Celsius, well above the maximum natural environment temperatures on Earth and above the maximum performance temperatures listed for the Boeing 737. They wanted the "hot" temperature, when the alloy tube would reach its maximum angle of change, set at about 250 degrees Celsius.

Writing the alloy recipe wasn't as simple as adding hafnium in small doses to a nickel-titanium mix. "I wish it was that easy," Benafan says. NASA's microstructures experts had to test the activation temperatures of nickel, titanium and hafnium mixtures measured by their atomic percentages, then add a few more atoms of one of the metals and test it again. They did that up and down the range of possible formulations for the three metals. Once they tested the range of possible formulations, they knew how to mix an alloy that would change shape at the specific temperatures they wanted.

The composition must always be exact. "If you miss, and you put in too much nickel or too much

NASA

▲ NASA operations engineer Patricia Martinez and support aircraft crew chiefs Norman Robertson and James Ford remove the right wing from an F-18 at NASA Armstrong Flight Research Center in California.

▶ By heating and cooling a mix of nickel, titanium and hafnium, NASA engineers can train tubes to bend when heated to a specific temperature and return to their original shapes when cooled.

The unmanned PTERA, an 11 percent scale Boeing 737, with wingtips that can be folded up or down during flight.

titanium, you're just going to get a brick. You're just going to get a tube that doesn't do anything," says Benafan.

Safely heating and cooling

The next question was how to safely heat and cool the tubes aboard the plane, given that they react only at unnaturally high temperatures. In the lab, heating an SMA tube is easy — just wrap a heating coil around it — and electric power supply is not a problem. But for the PTERA, the tubes have to be as lightweight and small as possible, while still exerting the required force. "You don't want to wait 30 minutes to move up and down; you want motion that is short and fast," Benafan says.

The answer was to place a cartridge electric heater inside each tube. For PTERA's winglets, the engineers designed the tubes — one for each wing — at about 1.3 centimeters in diameter and 20 centimeters long, and they bend the tips of the wing up to 70 degrees. The heater controls the bending by the tube to an exact temperature associated with a specific angle between zero and 70 degrees. To speed up the cooling, which reduces the angle of bend, rather than just turning off the heater, the engineers also designed a fairing with holes through it at the front of the wing. Cool ambient air rushes in to cool the tube to a specific temperature, when the heaters are turned off. For larger versions of the SMA actuator, such as for a warplane, engineers will build a door to open and close to let air in, and they may hook up a blower to direct even more cooling air at the tube. To bend the winglets down by a maximum of 70 degrees for the test plane, an engineer has to flip a connector on the wing between flights, which reverses the gearing in the actuator. But a plus-70-to-minus-70-degree actuator would be easy to design by adding gearing to the actuator, Benafan says.

Soon it will be test time for the actuator. NASA, Boeing and Area I plan to strap the plane down and ground-test all of its flight systems in November at Area-I's headquarters in Georgia. Then, for flight tests, an Area I pilot will remotely control the unmanned PTERA through takeoffs and landings

▼ **NASA plans** to ground-test the ability of a shape-memory-alloy to fold the wingtip of an F-18. Here, a 3-D mockup of the actuator rests on top of the wingtip, shown with Othmane Benafan, co-principal investigator for the Spanwise Adaptive Wing project.

from the dry lake bed at Edwards Air Force Base, California, where NASA Armstrong Research Center is. A computer will fly the drone once the pilot gets it airborne.

Improving a warplane

A key motivator for the Spanwise team was the near absence of research and testing on full-scale aircraft, Moholt says. "We were a little frustrated, because you see a lot of the work in this arena, and it's all subscale and there's no path to full-scale infusion," he says.

So, in addition to the upcoming PTERA flights, they are preparing to ground-test their actuators on an F-18, this time folding up and down a large section of wing. The engineers chose the F-18 for a simple reason: It already has folding wings, though just for parking, not for flight. Also, F-18s were available from the "boneyard" at Edwards Air Force Base. In July, Moholt and a crew at NASA Armstrong picked an F-18 from the boneyard and detached its right wing, crated the wing up and sent it on a flatbed truck to Benafan and his team at NASA Glenn in Ohio. The NASA Glenn team cleaned the bird droppings off and laser scanned the surfaces of the wing and its folding joint. The team is building a drop-in replacement actuator for the folding wing, which will mean removing the electric motors and gearbox that normally raise the wingtips for storage in close quarters.

A challenge was building the larger actuator that would be required for a highly maneuverable warplane. Until now, the largest SMA tube that engineers had worked with was the 1.3-centimeter-diameter version that will be tested on PTERA. For the F-18, they'll need tubes that are twice as large. This means relying on outside vendors to pour ingots that are larger than the Spanwise team can create in the lab. Hundreds of kilos of raw material are required. So far, they've scaled up to tubes that are twice as wide as the 1.3 cm version, starting from cylindrical ingots of the alloy about 18 cm thick and about 30 cm long. They then reduce the metal to a rod by forging and extruding — pressing the metal into dies — and drill out the center to make the tube.

NASA's engineers are confirming and testing the properties of these tubes by applying loads and heating and cooling them through hundreds of cycles of bending on a test rig. Next, they'll create and test the even larger tubes required for the F-18. "The material (for the larger tubes) looks good," Benafan says, but the engineers are checking if the properties of the smaller tubes translated to the larger versions. "Did we lose any strength? Did we lose activation temperatures?"

Stepping up to the larger SMA tubes brings some complications. Larger bearing structures will be required where the actuator meets the main wing and stronger clamps will be required to hold each actuator to the inside wing and the wing tip.

"All that becomes another level of challenge, because now you have a much bigger chunk of metal that you have to heat somehow. You need to carry much more power to heat them, let alone to cool them," Benafan says.

To get ready for the F-18, NASA Glenn engineers have built a test rig that will demonstrate that an SMA tube, or possibly a bundle of tubes, can bend 90 degrees with about 600 Newton-meters of force, and then about 2,300 Newton-meters. ★

NASA

▲ A test rig at NASA's Glenn Research Center in Ohio twists a nickel-titanium-hafnium shape memory alloy tube, painted white and wrapped in a copper heating coils. The metallic cylindrical grips above and below the tube hold it in place, while the bottom grip twists with 1,360 Newton-meters of torque, or more than twice the torque produced by a 2017 Ford F-150 pickup truck. The heating coil warms the tube, and the shape memory alloy responds by twisting and moving against the torque of the test rig. A digital camera records the movement as tracked through tiny black dots painted on the tube. Air blown through yellow sponge material cools the tube and it returns to its original position.

BY ADAM HADHAZY | adamhadhazy@gmail.

LIFE AFT STATION

ER

NASA

◀ **BEAM**, or the Bigelow Expandable Activity Module, was deployed on the International Space Station in 2016. Bigelow wants the foldable modules to serve as living quarters and workspaces on private stations in the future.

No one knows for certain whether the private sector will step up and continue the kind of drug and materials research pioneered aboard the International Space Station. Much will come down to the output of experiments over the next six years, a home stretch that will see the apex of science activity aboard the orbiting lab. Adam Hadhazy takes the current pulse of science and manufacturing prospects on-orbit.

Next year, the International Space Station turns 20. Just how many more birthdays the station will celebrate is up for debate. Congressional funding for ISS via NASA will continue through at least fiscal 2024, but the agency has made clear it wants to transition its portion of ISS to the private sector as soon as practicable. Doing so would free up an annual $3 billion-$4 billion in ISS operational costs for other pursuits, such as a crewed mission to Mars. If stakeholders cannot reach a new arrangement, they will be forced to deorbit ISS, scuttling by way of a fiery atmospheric re-entry terminating in the Pacific Ocean.

Helping NASA prepare humans for deep space exploration will be one probable revenue stream for the inheritors or successors of ISS. An admittedly shakier selling point, though, is delivering revolutionary advances in science and technology to people back on Earth. In his 1984 State of the Union address, President Ronald Reagan set the bar, appropriately enough, sky-high: "A space station will permit quantum leaps in our research in science, communications, in metals, and in lifesaving medicines which could be manufactured only in space."

Even ISS' most enthusiastic backers would agree this vision hasn't been realized — or, at least, not yet. That could soon change. After fits and starts, research is now humming along, with government agencies, universities and Fortune 500 companies all lining up at the launch pad with their experiments. Particularly promising areas include drug development by pharmaceutical firms and the manufacturing of new materials. Station advocates are counting on big developments ahead.

"Significant breakthroughs in science and technology from the ISS that could come to fruition over the next few years will be a significant part of the justification for future investment and whether we maintain the ISS, a private space station, or possibly several public and private space stations," says Eric Stallmer, the president of the Commercial Spaceflight Federation, a trade association representing more than 70 companies in the commercial space industry.

NASA intends to offer the certainty that the blooming private space industry will require. "We want to ensure continuity in U.S. human spaceflight and America's leadership in space and technology innovation as we look to the commercial sector to play a stronger role in low-Earth orbit, and as we focus on our efforts on deep space exploration.," says Bill Gerstenmaier, the NASA associate administrator for human exploration and operations. "The agency is engaged with the private sector to foster both commercial demand and supply for services."

Congress has taken a keen interest as well. In the

▼ **Government agencies,** universities and private companies want to get their experiments on the International Space Station, which is almost 20 years old.


NASA

NASA

▲ **The Cosmic-Ray** Energetics and Mass, or CREAM, instrument — shown at Kennedy Space Center in Florida in June — will be mounted on the ISS for three years measuring the charges of cosmic rays.

NASA Transition Authorization Act of 2017, signed into law in March earlier this year, the agency must begin producing biennial reports — the first of which is due in December 2017 — on the future of the ISS, including the steps NASA is taking in wielding the station to promote the commercialization of near-space and ultimately repositioning the agency as just one of low-Earth orbit's many customers.

Private station aspirants, such as Axiom Space, are already placing their bets on this imminent viability of low-Earth orbit. Co-founded in 2016 by a former NASA ISS program manager and the leader of the private aerospace services firm that operates ISS, Axiom plans to launch a module to the station in 2020. That module would then detach from the decommissioned ISS in 2024, forming the nucleus for a new, commercial station. The company thinks that, besides revenue from governmental space agencies and thrill-seeking space tourists, research and the manufacturing it eventually leads to will become the top moneymaker. "Manufacturing of products for use on the ground and in space is expected to overtake all these revenue streams," says Amir Blachman, the company's vice president in charge of strategic development.

Although critics have assailed the ISS program for its debatable returns on investment, having cost United States taxpayers north of $80 billion, according to the NASA Office of Inspector General, private firms and venture capitalists still seem more than willing to bankroll commercial development in the final frontier.

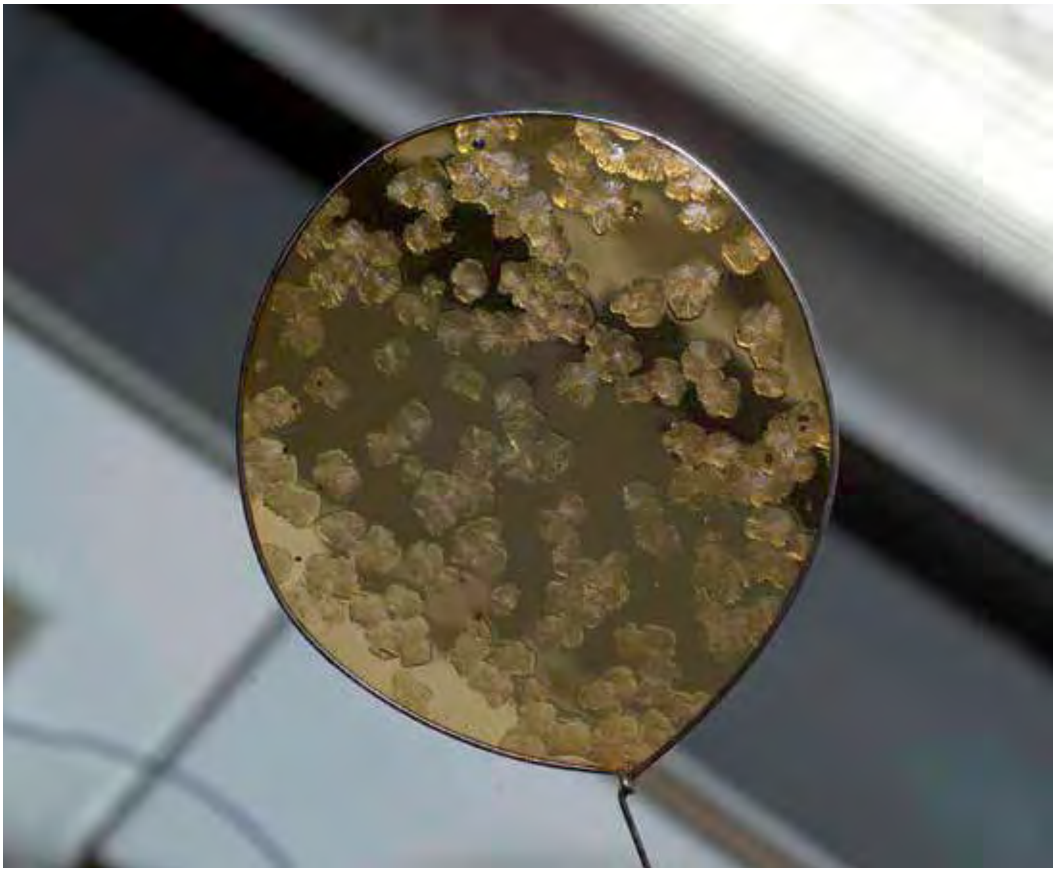
"ISS has been the base where humanity 'learned how to learn' in space," Blachman says. "Now, at the latter portion of ISS' lifespan, on-orbit research is starting to gain the capability and robustness that is attractive to industry, including biomedical, biopharma and materials companies."

A sea change in space

The recent flourishing of ISS research stems in large part from vastly improved access. The commercial space sector has filled the gap left by the 2011 phase-out of NASA's space shuttle. SpaceX's Dragon capsule and Orbital ATK's Cygnus spacecraft are rubbing elbows with spaceships from the Russian, European and Japanese space agencies, toting experiments on their cargo runs to ISS.

"We've never had more opportunities to go up and down from the station," says Ken Shields, the director of operations at CASIS, the Center for the Advancement of Science in Space, the nonprofit manager of the United States National Lab on ISS for non-NASA-related experiments.

In 2017 alone, 120 new experiments have flown, a record that gets broken with each passing year. Around 300 experiment-driven investigations happen over a typical six-month period nowadays — a far cry from the couple of dozen over a similar stretch circa 2004, says Julie Robinson, NASA's chief scientist



Crystals grown in microgravity are often of a higher quality than those grown on Earth.

for the ISS Program. The number and variety of research facilities and instruments on ISS has also expanded, offering scientists the chance to study a range of areas with potential terrestrial commercial applications. Educational outreach by CASIS has brought many new researchers and funding pipelines into the space fold.

ISS science is set for another boost starting in 2018 through NASA's Commercial Crew Program, provided the latest schedule holds. For the first time since the shuttle's retirement, American spacecraft — the Boeing CST-100 Starliner and SpaceX's Crew Dragon — will ferry astronauts to space. With reduced costs from flying people on these vessels versus buying seats on Russia's Soyuz, NASA's program will be able to afford posting an additional crew member on ISS, bringing the station's full-time crew complement to seven. That single extra person on board will actually double the amount of time available for conducting science experiments, thanks to re-apportioning of crew duties. "We're still on an ever-increasing trajectory," says Robinson.

"The growing demand for access to the space station enables the establishment of robust U.S. commercial crew and cargo capabilities," says Gerstenmaier. "Both of these aspects will help establish the U.S. market in low-Earth orbit beyond the current NASA requirements."

"THE ISS WILL END UP BECOMING JUST AN ORBITING PIECE OF INFRASTRUCTURE NOT BEING USED BY ANYONE UNLESS IT BECOMES VERY CAPITALISTIC."

— **Dick Rocket**, CEO and co-founder of NewSpace Global

Pristine micro-g

The allure of conducting many experiments aloft is the microgravity environment. The station's continuous freefall toward Earth, which is overcome by the lab's orbital velocity, renders everything onboard essentially weightless. This eliminates nearly all the pull of gravity that affects molecular movement at our planet's surface. "There's a set of experiments that scientists have been doing on Earth forever, and they can't do the one controlled experiment [they're] supposed to do," says Robinson. "You can't control

NASA

▲ **Astronaut Jack** Fischer works with the Neutron Crystallographic Studies of Human Acetylcholinesterase for the Design of Accelerated Reactivators, or CASIS PCG 6, experiment. The space station's microgravity enhances the growth of crystals, which in this case could be important to developing antidotes to poisons that attack the central nervous system.

gravity, because every experiment you do on Earth has it in it."

Microgravity can pay dividends when crystallizing proteins. New Jersey-based pharmaceutical company Merck has long recognized this potential, having sent crystallization experiments to space since 1993 aboard the space shuttle and continuing with ISS. Out from under gravity's thumb, crystals can grow larger, purer and more uniform in size. On Earth, proteins sediment out of crystalline structure or further disorder themselves through movement caused by internal heat currents. The higher quality of the crystals from space is easy to see, says Paul Reichert, an associate principal scientist at Merck leading the ISS investigation. "You can hold two of the bottles up and tell the difference right away between crystals from flight versus ground," he says.

Merck's principal interest in those crystals is for developing concentrated suspensions of its anti-cancer compound, Keytruda. Newly formulated in this manner, a dose of the drug could be administered through a syringe at a doctor's office, instead of burdensome, expensive, hours-long infusions at outpatient clinics or hospitals. The research could also lead to improved purification of the drug during manufacturing, reducing costs.

Keytruda works by inhibiting a "checkpoint" protein, PD-1, which blocks a patient's immune system from otherwise attacking cancerous cells. The medication belongs to a class called biologics that represent some of the fastest-growing and top revenue-producing drugs on the market. As part of Merck's agreement with CASIS, Reichert says the research will be published publicly for other companies and their patients' benefit.

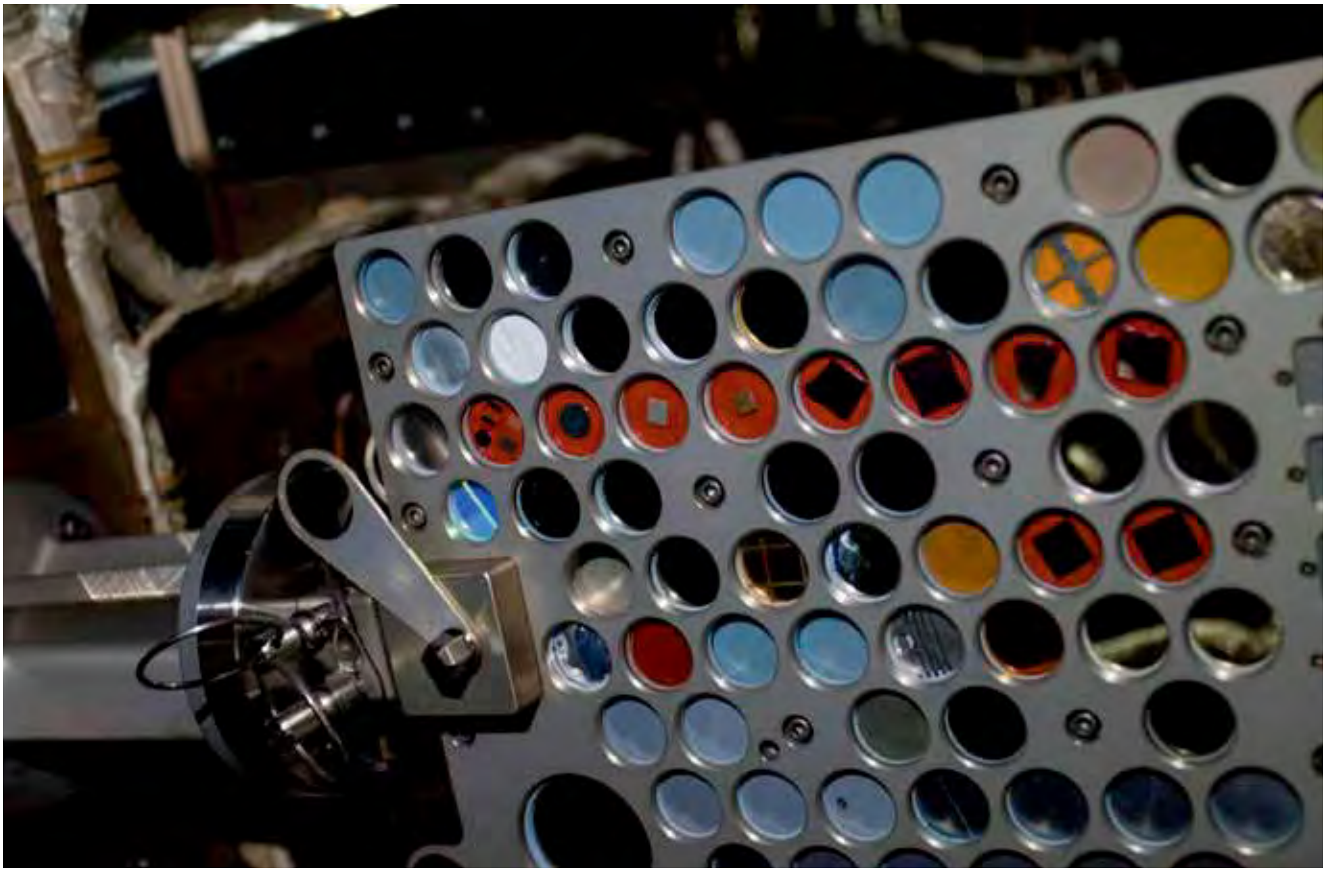
Parallel research is also leveraging better-quality protein crystals for discovering entirely new drugs. An imaging technique called X-ray crystallography allows scientists to obtain three-dimensional pictures of a protein's shape. Knowing the shape opens the door to tweaking a protein so it effectively binds to target molecules. Or, oppositely, the approach can reveal "druggable" sites where a protein of interest may be targeted. An example is LRRK-2, a gene whose protein product is implicated in triggering the neurodegenerative disorder Parkinson's, and which the Michael J. Fox Foundation sent to the station back in August 2017 having struggled to crystallize it on Earth. [See "Space station experiment targets Parkinson's" in Aerospace America's September issue.]

The future is bright for these modes of research because of their unique insights, Reichert says, but he urges patience. "Before you discover a new drug, it may be 10 years of research to get to that point — and that's on Earth," he says. "I can do a hundred experiments here [at Merck] a day," whereas on ISS, "I have the opportunity to do one experiment a year."

Should pharmaceutical breakthroughs in microgravity prove nontransferable to drug-making on terra firma, a strong case could emerge for constructing on-orbit specialty drug factories.

Exotic fiber optics

Another promising materials science effort, focusing on fiber optic cables, could also buttress arguments for commercial space station manufacturing.



NASA

▲ **The MISSE-8**, or Materials on International Space Station Experiment-8, was mounted on the space station's exterior to test the effects of space on certain materials.

One company exploring the possibility is California-based Made In Space. Known for building the first 3-D printers ever used off-Earth (aboard ISS), the company plans to send up a new type of machine in December. Dubbed the Fiber Payload, it's slated to generate 100 meters of fiber optic cable composed of a specialized glass called ZBLAN, named after its constituent heavy metal fluorides. In Earth's gravity, pulling ZBLAN out into threads introduces bubbles and crystallizations that limit the material's light transmission efficiency, making it no better at conveying data than conventional, silica fibers.

In theory, however, extremely pure, clear ZBLAN manufactured in microgravity would experience 100 times less light power loss over its length than silica. That would slash the expense associated with needing a lot of optical communications repeaters, which receive a weak signal and retransmit it in amplified form, to send telecommunications data over long distances. Plus, ZBLAN conveys infrared light better than silica, so bandwidth could increase, too. Though the space-fashioned fiber would cost considerably more on its own, lower total installation expenses should make it competitive while offering greater performance, says Jan Clawson, the Made In Space fiber optics program manager.

Clawson says he can't give away how the Fiber Payload works exactly. But he allows that the automated, locker-sized piece of equipment will include a miniaturized fiber draw tower, similar to conventional manufacturing setups on Earth, operating in a contained, inert environment. Made In Space has big hopes for the experiment; if high quality is achievable, it "could result in complete large-scale adoption in long-haul communications," says Clawson, "and potentially open up a multibillion-dollar market segment for a space-based product."

Axiom Space, the private space station developer, has taken notice. The two firms announced a partnership in January to pool their knowledge and skills and establish a genuine manufacturing base in orbit.

More than microgravity

Many other commercial applications do not exploit the station's freefall, but rather its vantage point 400 kilometers above Earth in the desolation of space. The Houston company NanoRacks helps clients with ISS utilization and is best known for deploying inexpensive cubesats. These tiny spacecraft run experiments in areas including Earth observation and exposing materials to space's hard vacuum and radiation.

The San Francisco-based firm Planet, meanwhile, relies on NanoRacks' ISS-mounted launcher to add cubesats, nicknamed Doves, to its constellation of satellites that constantly photograph the world below. Clients are involved in areas such as disaster relief, civil government, crop monitoring and deforestation tracking.

THE COMMERCIAL SPACEFLIGHT FEDERATION'S ERIC STALLMER SUGGESTS CORPORATE RESEARCHERS MIGHT SOON SERVE STINTS ON ISS, BRINGING THEIR EXPERTISE AND TRAINING RATHER THAN RELYING ON GENERALIST ASTRONAUTS TO CONDUCT EXPERIMENTS.

CASIS' Shields says numerous startup companies with real commercial potential will be making a go on ISS over the next year. Cynthia Bouthot, the director of commercial innovation at CASIS, says economics factor into those proposals ultimately getting the green light. "We look at the economic benefit, the innovation-in-science benefit, and the humankind and social impacts as we evaluate projects," she says.

A crowded space

Dick Rocket, CEO and co-founder of NewSpace Global, a business intelligence firm focused on space commercialization and technology, offers a telling statistic on how fast the sector is growing. "When we started in 2011, we were tracking a hundred companies for their commercial space interests," he says of his company, located on Florida's Space Coast. "Since then, it's gone up one order of magnitude to over a thousand."

The ISS has been the reliable hub and destination for much of this burbling entrepreneurial activity in space. But for the ISS to remain relevant over its remaining lifetime and pave the way for a privately owned station or stations, Rocket says commercialization must kick into a higher gear. "The ISS will end up becoming just an orbiting piece of infrastructure not being used by anyone unless it becomes very capitalistic," he says. Just as Kennedy Space Center in Florida now has the logos for private companies including SpaceX, Boeing and Blue Origins adorning launch infrastructure previously operated by NASA, so, too, should the space station's American modules be leased and branded accordingly, Rocket argues.

One logo up on ISS already is that of Bigelow Aerospace. The Las Vegas-based company in May 2016 deployed an inflatable, room-sized module on ISS that has become a popular nook for astronauts. Bigelow intends for these foldable, fabric, vinyl and aluminum modules to serve as living quarters and workspaces on private stations to come. The company wants to send up a much larger module in about 2020, potentially vying with Axiom Space for access to the last unused port on ISS. Meanwhile, a third group called Ixion — comprised of NanoRacks, Space Systems Loral of California and United Launch Alliance, the joint venture of Lockheed Martin and Boeing — also has plans to dock an Atlas 5 rocket's spent Centaur upper stage to the ISS. The effort would gauge the feasibility of linking together mostly pre-built, refurbished components for a potential new extraterrestrial outpost.

With more infrastructure space-bound, people will follow. The Commercial Space Federation's Stallmer suggests corporate researchers might soon serve stints on ISS, bringing their expertise and training rather than relying on generalist astronauts to conduct experiments. Such an approach would hearken back to the payload specialists of the shuttle days. "I could see companies like Pfizer sending engineers up to do experiments," says Stallmer.

Inevitably, the ISS and post-ISS orbital economy will have to deal with accidents and losses of life, not just costly ships and cargo. "Spaceflight will always be expensive for humans," says Sam Scimemi, the division chief for the space station at NASA headquarters in Washington, D.C. "It will always be a riskier business than driving a car or flying an airplane. There will continue to be accidents in flight because our understanding of this technology is not perfect."

NASA's Robinson offers an analogy of the history of oceanic travel for how she sees the science and commercial landscape evolving for low-Earth orbit. "If you go clear back to Magellan, exploring the ocean was pretty deadly," she says. His voyage in 1519 that circumnavigated the globe for the first time started from Spain with 270 crewmembers and retuned home with 18, Magellan not among them. Three centuries later, the voyage of the HMS Beagle brought along scientists, including a young Charles Darwin, on a multi-year expedition, and still some deaths occurred. Nowadays, science vessels ply the waters, but so do cruise ships for pleasure, and most of the traffic on the high seas is commercial container ships. Maritime accidents are infrequent and few people bat an eye at the concept of gigantic vessels exposed to the dangers off of land, instead enjoying the fruits of science and technology strewn by worldwide seafaring.

"The oceans are part of our economic sphere on Earth," says Robinson. "And we want low-Earth orbit to be part of the sphere." ★

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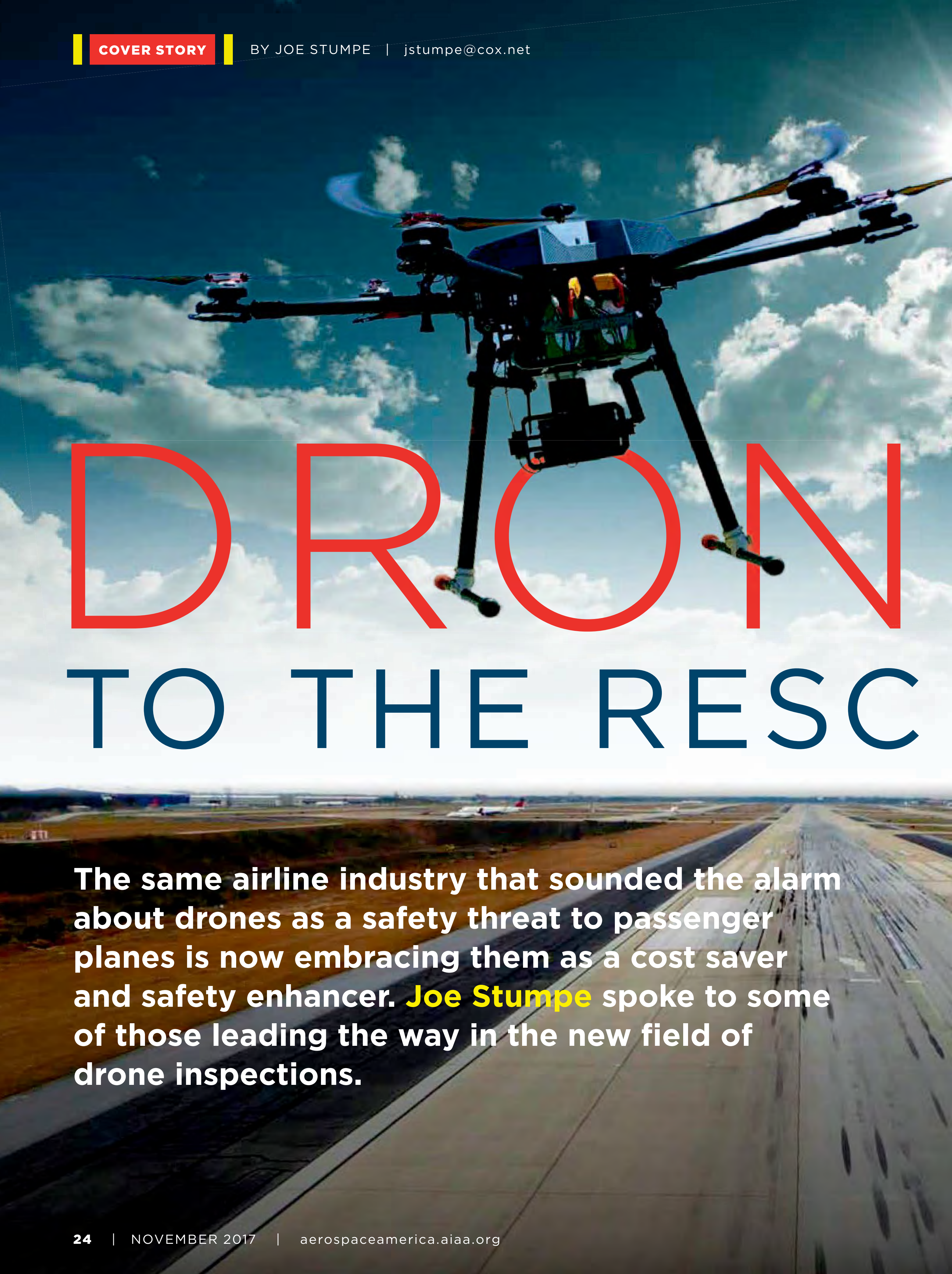


DRON
TO THE RESC

The same airline industry that sounded the alarm about drones as a safety threat to passenger planes is now embracing them as a cost saver and safety enhancer. Joe Stumpe spoke to some of those leading the way in the new field of drone inspections.

Canard Drones says its quadcopters help calibrate runway lights called precision approach path indicators. In this photo illustration, a Canard quadcopter is superimposed on a runway at Hartsfield-Jackson Atlanta International Airport.

Canard Drones

A pilot since the age of 18, Jim Duguay was in his 40s when he took up flying drones for his employer, Pittsburgh-based Michael Baker International, whose line of business includes civil engineering and consulting for airports. When he first flew a 3.06-kilogram quadcopter over the longest runway at Hartsfield-Jackson Atlanta International Airport to look for pavement stress and other signs of deterioration, he came away impressed by drones.

"I think they've almost become like flying iPads now," he says. "The automation that is put into the technology is amazing."

Duguay's wake-up call is being mirrored across the aviation industry. Just a few years ago, much of the talk about drones and airplanes was about the danger they presented to passenger planes. As drones proliferated among hobbyists, filmmakers and others, so did concerns about what would happen if one crashed into an airplane, got sucked into an engine or caused a pilot to swerve out of its way.

"Three years ago, it was 'No, stay away, don't invade the airspace'" with drones, says Jordan Cicoria of Aerium Analytics, which has been flying a drone to scare birds away from the Edmonton International Airport in Alberta, Canada. "But you're having a lot more people start to embrace it."

Today, the conversation is still about keeping airspace safe for planes that carry people. But it's also shifting to the ways in which drones can help the aviation industry lower costs, become more efficient and — yes — safer. In the case of runway maintenance, for instance, the drone's high-resolution camera picks up things the human eye might miss and makes it easier for engineers to spot structural changes over time.

Most new uses of drones in aviation are still in their experimental stages, with Canada and European countries ahead of the United States in that regard. Duguay's two drone flights at Atlanta's airport are still being evaluated for their benefits, while the Edmonton flights are a five-day-a-week part of the wildlife control program. But few doubt that the world's biggest aviation market will catch up.

As John Goglia, head of the Professional Aviation Maintenance Association and a former member of the National Transportation Safety Board, says: "I suspect the United States will be in with both feet in the near future."

Aircraft inspection time-saver

In Europe, two companies are touting drones for the inspection of commercial airliners, a job they can complete in a fraction of the time it takes humans to do. Today, speeding up inspections would reduce aircraft downtime and reduce expensive man-hours spent towing aircraft into hangars and pulling out scaffolding and cherry pickers to reach the upper parts of the plane. Drones can be programmed to fly around and photograph planes — using different flight paths for each make of plane — in about a fifth or less of the time it now takes.

"It's still early but there certainly is a lot of interest from airlines and companies in reducing the time it takes to do normal visual inspections," says Gavin Goudie of Blue Bear Systems Research, co-developer of an inspection drone called RAPID (Remote Automated Plane Inspection & Dissemination) that's being tested by London-based easyJet.

▼ A team from Michael Baker International inspects runways with drones over Hartsfield-Jackson Atlanta International Airport.

Michael Baker International

A quadcopter with a half-meter wing span, RAPID has electro-optical sensors that detect damage from lightning strikes, hailstones and other hazards, while a lidar sensor helps guide it.

Maintenance workers automatically deploy RAPID, although they can assume manual control.

"The big win," Goudie says, is that skilled employees can spend more time analyzing data collected by the drones, instead of manually conducting the inspections themselves.

The drone's avionics keep it at least 1 meter away from the aircraft it's inspecting, to avoid damaging it, and feature a collision avoidance system to dodge people or objects that might come into its path. Operating inside a hangar is an advantage, since licenses aren't required to operate a drone in "private field environments" in most countries, Goudie says.

Some two years after the first demonstration drone, Goudie says the company is "very close to getting our system deployed," with other airlines in Europe and the U.S. interested in it as well.

"The whole point of the system is it's not another drone, it's another tool for the aircraft industry," Goudie says.

Donecle, a France-based developer of aircraft inspection drones, has been testing its 80-by-80-centimeter drone with Air France-KLM Engineering & Maintenance for about the same period. Josselin Bequet of Donecle says fully automating the drone — "removing the pilot and having the drone fly on its own" — was the key to making it attractive to potential users.

According to the company's website, starting an inspection "is as simple as selecting your aircraft type, setting the drone next to the aircraft and hitting 'Go.'" More than one drone can simultaneously inspect a larger aircraft.

The drone was initially flown to inspect regulatory stickers on aircraft, but the company realized it could expand its role to spotting lightning damage, says James Kornberg, director of engineering and maintenance innovation for Air France.

A drone can complete an inspection in 20 minutes, compared to the five hours it takes employees, and the data it collects is automatically stored and easily traceable in a secure cloud-computing environment, Kornberg says. Donecle's website says it costs $27,000 to completely inspect a commercial aircraft using traditional methods, not figuring in the $80,000 lost while the aircraft is on the ground.

Bequet says the drones have inspected hundreds of A320s and other aircraft. "The solution is pretty much operational," and Donecle expects it to be rolled out across airports serviced by Air France in the near future.

Airbus announced last year that it is testing

"RATHER THAN DOING VISUAL ON-FOOT PAVEMENT INSPECTIONS, WE UTILIZED DRONES TO COLLECT HIGH-RESOLUTION IMAGES. THE THOUGHT WAS THAT WOULD REDUCE DOWNTIME OF THE RUNWAY."

— Jim Duguay of Michael Baker International

drones to inspect its A330 aircraft. According to the Airbus website and a YouTube video posted by the company, the drone digitally photographs the upper part of the aircraft during the final inspection when the manufacturer is looking for cosmetic defects such as scratches and dents. The drone can cover an aircraft in 10 to 15 minutes, compared to the two hours it takes a human (although a human must review the photographs). The drone helps prevent worker injuries because an employee no longer has to go up in a lift to see the top of the plane, according to the company. Airbus said the drones would be tested on other aircraft beginning this year.

Preventing wildlife incursions

Reducing the time and cost involved in inspections might be the biggest potential benefit of drones in aviation, but it's not the only one. Edmonton International Airport in Canada earlier this year started flying a drone for wildlife control, specifically to scare birds away from the paths of aircraft.

The drone, called Robird, weighs just 750 grams and, with its flapping wings, looks to other birds like a falcon attacking its prey. It was developed by Clear Flight Solutions of the Netherlands and is operated at the airport by Aerium Analytics of Calgary. The partnership between Aerium and Clear Flight came about after a meeting among executives at an aero-

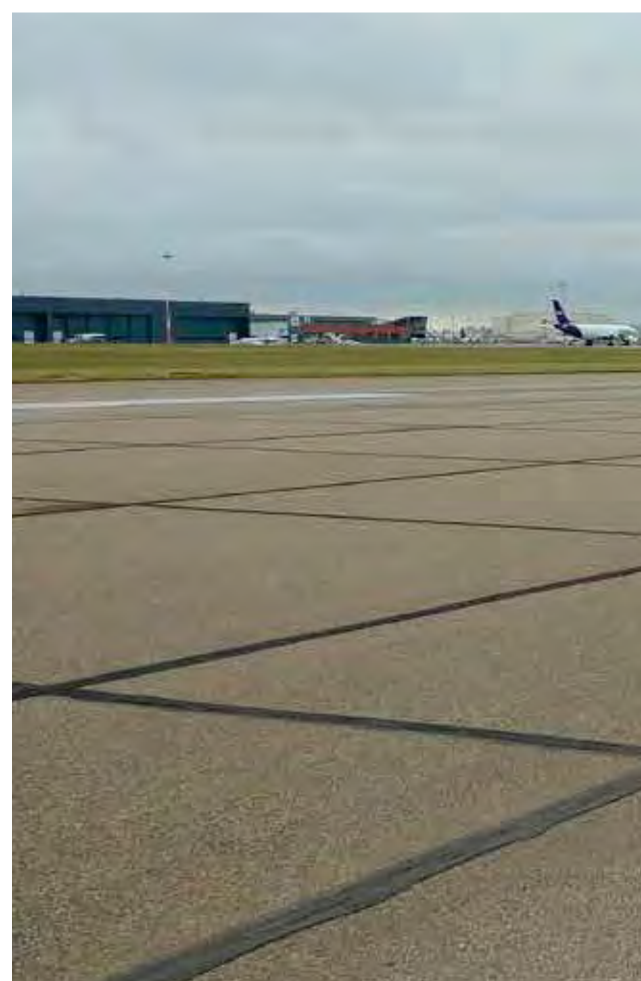
▼ **An inspection drone** called RAPID for Remote Automated Plane Inspection and Dissemination is being tested by easyJet to detect damage from lightning strikes and other hazards.

Blue Bear Systems Research

Aerium Analytics flies

"THE WHOLE POINT OF THE SYSTEM IS IT'S NOT ANOTHER DRONE, IT'S ANOTHER TOOL FOR THE AIRCRAFT INDUSTRY."

— Gavin Goudie of Blue Bear Systems Research



Aerium Analytics flies versions of a Robird drone at the Edmonton airport in Canada to repel birds that interfere with aircraft.

space conference in Japan. Robird had previously been assigned to chase birds away from an orchard, among other applications.

"We immediately saw the need for technology like that in airports in North America," Cicoria said.

Under Transport Canada rules, the drone can only be flown 122 meters high and the same distance away from active planes. Anyone flying in or out of the airport is notified of Robird's scheduled flights. The drone, which is steered by a pilot on the ground, can be dropped to the ground quickly if an aircraft appears in the area.

"Obviously, safety is absolutely paramount with these operations," says Dean Ervin, the airport's director of airside operations.

Ervin thinks it's too soon to determine Robird's effectiveness in controlling wildlife compared to traditional methods, although birds certainly seem to be afraid of it.

As far as safety, he says, "Obviously with drones in an airport, everybody gets a little nervous." That being said, "We've had no issues whatsoever."

Michael Baker International

Several other airports in Canada have expressed interest in Robird.

Duguay says there's also been some interest from airports in scanning runways for debris, typically parts from aircraft, with drones.

In 2000, an Air France Concorde was brought down by a small metal strip on a runway at Charles De Gaulle Airport. The strip ruptured a tire during takeoff, and the resulting debris pierced one of the plane's fuel tanks as it went airborne, causing a crash that killed all 109 aboard and four people on the ground.

"Drones are not going anywhere, so we're embracing the technology, but we're also making sure the safety requirements are followed to the nth degree," Ervin says.

◀ **The longest runway** at the world's busiest airport, 27R at Hartsfield-Jackson Atlanta International Airport, is seen in an image shot by a drone.

▼ **A drone** under the control of Aerium Analytics employees flies over Edmonton International Airport in Canada in September.

Aerium Analytics

French government accident report

◀ **This piece of metal** on a runway is believed to have brought down an Air France Concorde at Charles De Gaulle Airport in 2000.

"It's all about trust"

Aerium Analytics has flown a second, more traditional drone to map the Edmonton airport's runway and other features. Other possible uses for drones that have been discussed within the aviation industry include airport security, disaster response and the delivery of airplane parts.

"It's all about trust" between drone operators and aviation industry members, Cicoria says.

So far, the best-known use of drones in the U.S. aviation industry has come at Atlanta's airport. A drone helped plan a construction project in February and another photographed 27R, looking for defects on the longest runway at the busiest airport in the world. Duguay piloted the drone on those mapping missions. Such flights need special approval by the FAA and were conducted while the 3,776-meter-long runway was not in use, at a height of 30 meters. The job took about half as long as a traditional inspection.

"Rather than doing visual on-foot pavement inspections, we utilized drones to collect high-resolution images. The thought was that would reduce downtime of the runway," Duguay says, noting that the drone is capable of collecting "a lot more information than you would on foot."

More recently, the drone took video of a 5K footrace held on a runway at night at Hartfield-Jackson. While not directly related to aviation, the flight showed the FAA's willingness to allow drones to fly in airport space under a waiver process. Duguay says airports and the FAA are in a "learning process" regarding drones.

"Airports have been spending a lot of time ensuring that drones stay away from airports, for good reasons," he says. "There's a large hobbyist market out there and there's very little guarantee that these folks will follow all the safety regulations."

Blue Bear Systems Research

▲ **Blue Bear Systems** Research's quadcopter has avionics that keep it at least a meter from the aircraft it is inspecting.

But as drone technology improves to include safeguards such as geofencing, he adds, some airports are getting more comfortable with the idea of deploying them. "It goes down to the individual airport as far as whether they're interested in it." Duguay notes that in the case of the Inspire quadcopter he flew, he had to work with the manufacturer, DIJ, to disable the lock that would otherwise prevent it from flying in airport airspace.

Goglia of the Professional Aviation Maintenance Association has no doubt the aviation industry will continue to find uses for drones, just as so many other industries are.

"It's moving into every facet of our lives," he says. "Anywhere where it's more convenient to take a view from above, you're going to see drones in use. This is emerging technology. This is just starting." ★

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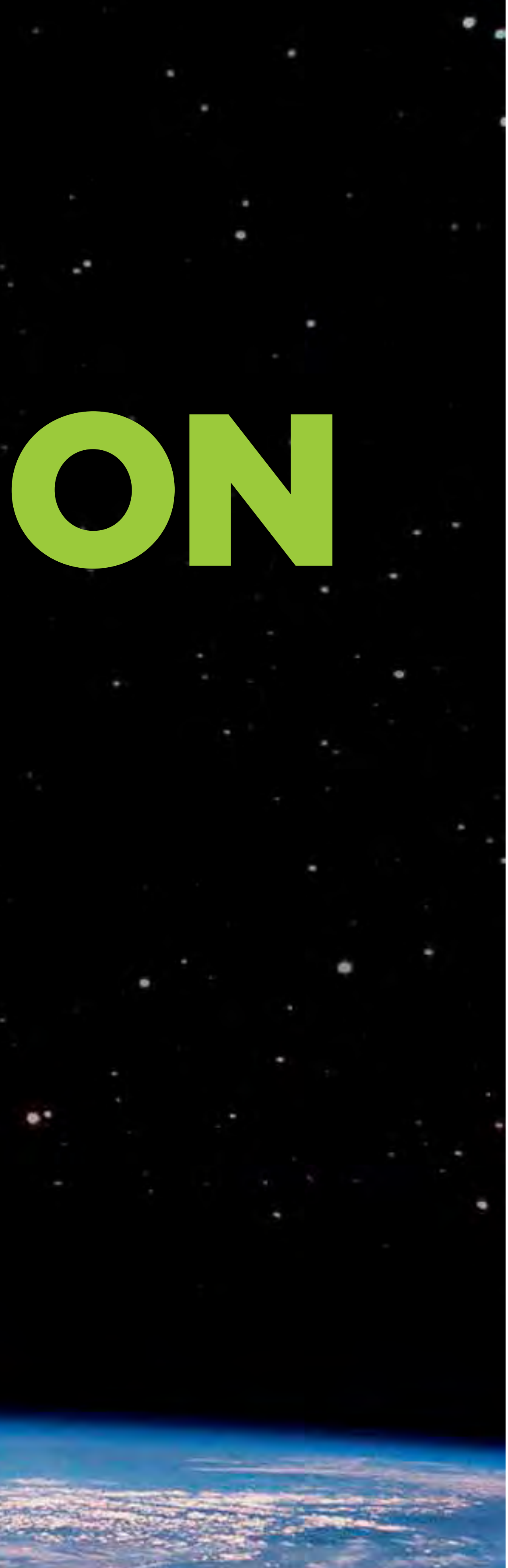
CONNECTI
QUANDRY

The Wideband Global Satcom constellation is a group of military communications satellites. This is an artist's rendering of WGS Block 2. The U.S. Air Force is evaluating whether to go with its own set of satellites in the future or to contract for services from a commercial provider.

Boeing



Today's commercial satellites have bandwidth capabilities nearly identical to those of the Air Force-operated Wideband Global Satcom constellation. Tom Risen looks at the possibility for a larger commercial role in U.S. military and government satcom after 2030 and possibly much sooner.

BY TOM RISEN | tomr@aiaa.org

Shortly after Doug Loverro became U.S. deputy assistant secretary of defense for space policy in 2013, he was shocked to find that military communications were coursing over Apstar 7, a geosynchronous communication satellite operated by APT Satellite Holdings. Among APT's top shareholders was a company operated by the Chinese government. In Loverro's view, communications via Apstar 7 ran the risk of being decrypted by China. Within a month, he was on Capitol Hill explaining to a congressional subcommittee how this situation came about.

In 2012, the Pentagon needed satellite communications for troops in North Africa. Bandwidth from the usual commercial suppliers was all booked up. The Air Force-operated Wideband Global Satcom constellation, a network of school-bus-size satellites built by Boeing specifically for broadband communications, was busy supporting other missions. The new constellation, which at the time was not complete, was being tugged in many directions, from sending intelligence dossiers to far-flung stations to presenting commanders with battlefield maps layered with data to sending diplomatic cables for the State Department.

So the Defense Information Systems Agency, which leases bandwidth from companies to supplement military constellations, saw that Apstar 7 was perfectly positioned over the Indian Ocean to serve North Africa and had bandwidth to spare. DISA signed a contract with Hong Kong-based APT.

Looking back, Loverro, who left government in January, says the Pentagon could have avoided the predicament by establishing partnerships with fully vetted satellite operators based in allied nations that would commit to providing additional bandwidth on short notice. The predicament was eye-opening too, because Loverro, in another Pentagon role in 1996, had advocated creating what we now call WGS. Even this powerful new constellation could not handle the demands of a growing mission in Africa.

Today, the Pentagon's long-term vision for broadband communications remains a work in progress. The Air Force, with a nudge from Congress, is working to change that. At issue is whether the Air Force will acquire, own and operate a multibillion-dollar successor to the WGS constellation, or whether the time has come to trust that commercial satellites will be available to take over all WGS's duties, or some subset of them when that time comes years from now.

The service is in the midst of a congressionally ordered "analysis of alternatives" to gather and assess options for meeting the military's broadband needs. The Air Force aims to transition to the resulting satellite communications strategy beginning in 2023, and have it up and running by 2028 when some of the WGS satellites reach the end of their 14-year design lives.

The satellite industry views the analysis as a chance to tackle some of the Pentagon's bandwidth problems much sooner.

Air Force Maj. Gen. David Thompson says it's "unlikely" that any future service that fills the WGS void will be purely owned by the military or by private companies. "The purpose of the [analysis of alternatives] is to look at the right mix of commercial and military systems," he says.

"When you compare WGS to commercial, I don't think there is a huge [security] difference. I think the Pentagon is underestimating the broadband capacity it needs."

— Rick Lober, general manager of the Hughes Network division

Security considerations

An underlying question is whether the Air Force and others in the defense establishment can accept not owning and operating a critical piece of defense technology, in this case a satellite constellation. Thompson cautions against allowing this cultural factor to stand in the way of more effective partnerships with companies. Thompson, who advises Air Force Gen. John Raymond, commander of Space Command, on budget and strategy, says satellite security is a more practical concern than "this is the way we've always done it."

Any commercial option would have to provide adequate security for defense, intelligence and diplomatic traffic. Indeed, defending satellite communications against signal jamming is perhaps the biggest security hurdle, Thompson says. Jamming can happen accidentally, such as when signals from two satellites are transmitted on a similar path and frequency and interfere with each other. Or a jamming signal can be sent intentionally with gear available in many electronics shops.

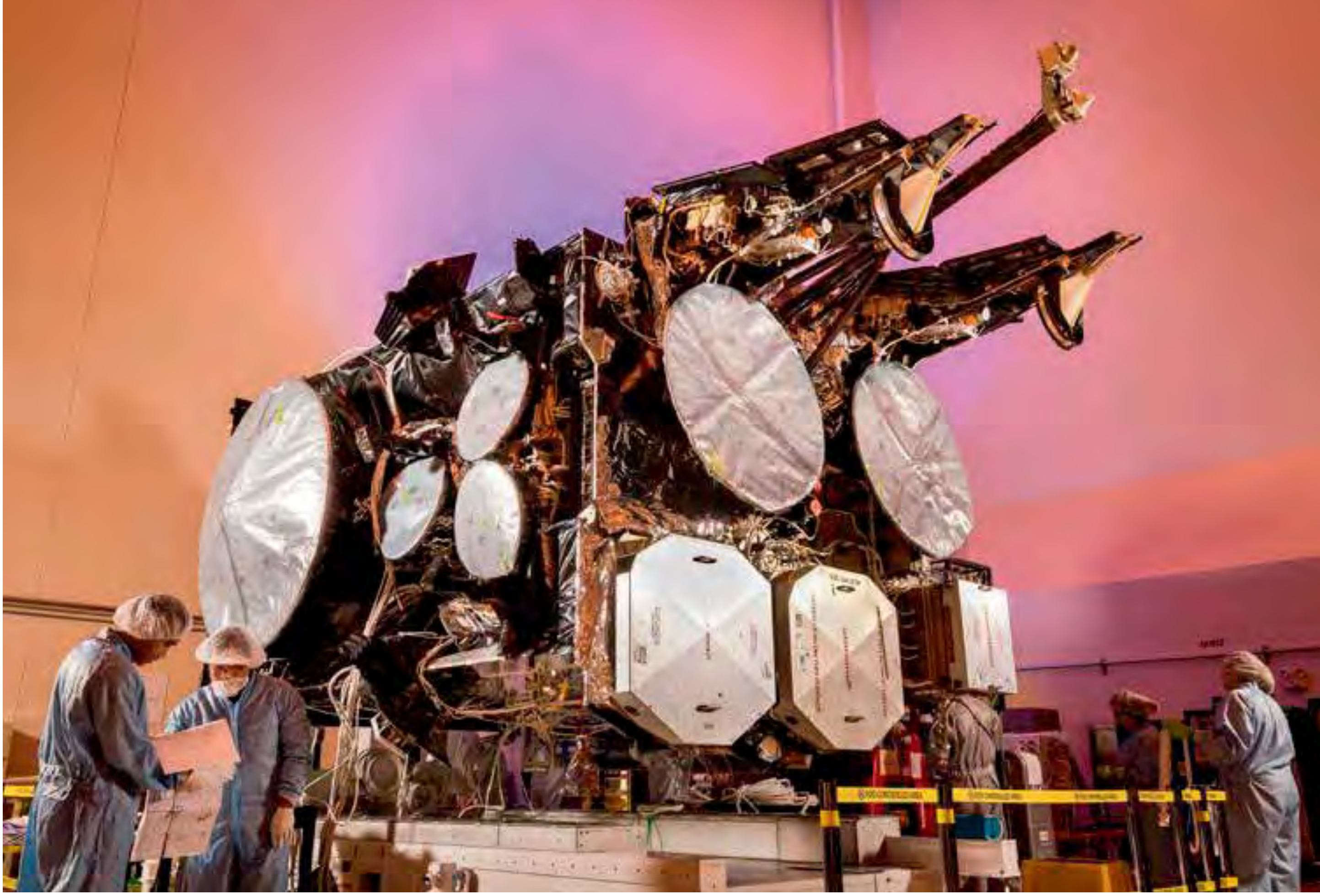
The WGS satellites aren't entirely helpless when it comes to jamming. Each "has a little bit of extra jam resistance built in" compared to the average commercial satellite, Thompson says. A phased array antenna and onboard processor on each satellite determine the nature and level of energy coming from signals in different regions. If the signal is too strong, the processor concludes that it's an attempt to jam the satellite's signal. The antenna then shapes its beam to decide what location to receive and send transmissions to.

Then there are the signals themselves. The Pentagon plans to shield satellite communications from jammers by transmitting them in a protected tactical waveform, a spectrum-hopping, spreading, and coding scheme that tailors a signal so it can be read only by a corresponding modem or antenna — like encryption with coding. That waveform encoded signal will then hop the transmissions it sends through alternating spectrum frequencies as an extra precaution. This signal encoding waveform could also be extended to protect commercial satellites.

Even so, "When you compare WGS to commercial, I don't think there is a huge [security] difference," says Rick Lober, general manager of the Hughes Network division, which connects defense and intelligence agencies with satellite communications. "I think the Pentagon is underestimating the broadband capacity it needs."

Shifting more military communications traffic to commercial satellites also could have strategy implications for potential adversaries. Actions by China and Russia suggest that each is devising ways to destroy satellites. China launched a missile to destroy one of its own weather satellites in 2007, and Russia in 2015 raised suspicions by maneuvering a satellite close to foreign satellites. Relying on commercial satellites to carry more Pentagon communications would "absolutely" put those satellites at risk of being targeted as military assets, Thompson says, which would place civilian internet services in danger.

The anti-satellite work of China and Russia is one reason Loverro opposed the Air Force's proposed Transformational Satellite constellation in 2007 when he was executive director of Air Force Space Command's Space and Missile Systems Center in Los Angeles. The constellation would have sought to handle all the Pentagon's satellite transmissions, including the sensitive messages now handled by WGS and the even more secure communications to command nuclear weapons. Loverro says there should always be a military-owned satellite for nuclear command and control, but TSAT was too pricy and "destined to fail." The Obama administration rejected TSAT in 2009 because of its expense.



Lockheed Martin

▲ **U.S. military commanders** and White House personnel communicate through Advanced Extremely High Frequency satellites when they need the most protection against signal jamming. Hear, workers at Lockheed Martin's Sunnyvale, California, manufacturing facility build one of the satellites.

"It broke Sun Tzu's warning about not massing all your forces in one place," Loverro says of TSAT, citing the Chinese general who wrote "The Art of War."

Broadband coverage gaps, like the one Loverro explained to lawmakers in 2013, create a vulnerability that, in a previous assignment in 1996, Loverro sought to prevent. Working under then-Secretary of Defense William Perry, he built bureaucratic and political support for the idea that became WGS.

The analysis addresses these kinds of everyday communications, rather than communications that must be sent even more securely than WGS and its commercial counterparts can manage. When commanders or White House personnel need maximum satellite jam resistance, they communicate through the Air Force's nearly completed Advanced Extremely High Frequency constellation in geosynchronous orbit. If jamming is detected on one frequency, transmissions can be hopped to another. Jamming signals transmitted from the ground can be avoided altogether by relaying signals among the satellites and their cross-link antennas until the network finds a safe ground terminal to connect with. The AEHF anti-jamming defenses also encode its signal with a classified version of a waveform that shapes a transmission so that only a friendly antenna or modem can read it.

The AEHF satellites are about the same size as their WGS counterparts, but they are more expensive in part because they have redundant hardware, self-repairing software and extra aluminum shielding to withstand the electromagnetic pulse from a distant nuclear explosion and continue operating. Northrop Grumman is scheduled to build communications technology and processors for six of those Air Force satellites built by Lockheed Martin, five of which have been launched.

A commercial reserve fleet in space

A Pentagon study in 2014 concluded that building and operating a new military-owned communications satellite would be less expensive than leasing bandwidth from companies. Thompson says that study is misleading because today's bandwidth procurement process is not cost-effective. The Defense Information Systems Agency searches the private sector to lease between 70 and 85 percent of the satellite bandwidth requested by the White House, the Pentagon and defense-related government operations each year, depending on the data traffic demands. A Government Accountability Office report in 2015 called this commercial bandwidth procurement process "fragmented and inefficient."

"I think our biggest obstacle in making commercial satcom more effective for the Department of Defense is the Department of Defense," says Thompson. "We haven't aggressively negotiated for the types of things we need. We generally tend to lease tran-

U.S. Air Force

▲ **U.S. military forces** depend on secure satellite communications to operate unmanned aerial vehicles such as this MQ-9 Reaper, as well as other weapons.

sponders and bandwidth rather than looking at it in a service-based approach, or trying to buy services and capacity that we might apply globally rather than one-by-one."

Numerous companies, NATO and up to 16 governments are contributing research to the analysis of alternatives in hopes it will show how to procure bandwidth on short notice with less expense wherever it is needed, says Air Force Col. George Nagy, who is overseeing the analysis.

Multiple working groups are involved, with a goal of helping the Defense Department "figure out how to be a better customer and a better user of [wideband] services," Nagy says.

Long satellite lifespans

The Air Force has the time to be thorough. The WGS satellites could operate beyond their 14-year design lives, possibly for decades. In fact, five of the Defense Satellite Communications System satellites that preceded WGS are still operational, even though the oldest spacecraft was launched in 1993. The first WGS satellite was launched in 2007 and reaches the end of its design life in 2021. The 10th and final WGS is scheduled for liftoff in 2019.

Given that outlook, the Air Force has laid out a multiyear schedule to find the right answer for post-WGS communications. Nagy estimates the first phase of the analysis of both military and commercial wideband options will be complete before September 2018. The next two phases will refine those ideas and lead to technical demonstrations in 2019 to show how the proposed connections would operate.

The analysis will examine the hosted payload concept of placing military or government communications antennas and electronics on a commercial satellite that would share its transponder and power source. Intelsat, for instance, launched a GPS signal booster for the FAA on one of its satellites in 2005, and a UHF transmitter for the Australian Defense Force hitched a ride on Intelsat's IS-22 satellite in 2012 to save the cost of purchasing rockets.

Another option under consideration in the analysis would be to place commercial and military bandwidth in a single network that could tap corporate bandwidth when needed, similar to the Civil Reserve Air Fleet agreement for airlines to transport troops when needed.

Maryland-based Hughes Network Systems, which is contributing to the analysis of alternatives, wants to manage such a network on behalf of the Pentagon. The network would connect commercial and military bandwidth into one full-time resource instead of an emergency afterthought. Doing so would make it easier for commercial technology including drones to operate on military frequencies, and vice versa, says Lober of Hughes.

Marco Caceres, director of space studies for the Teal Group market research firm in Virginia, says successful satellite partnerships between companies and militaries in Europe are debunking the argument that it is better for a military to own its satellites. Paris-based Astrium Services, a subsidiary of the Airbus Group, operates the Skynet satellites for the British government, and Rome-based Telespazio operates the Sicral satellites that provide military communications to France and Italy. Caceres says the U.S. faces less pressure than European countries to partner with companies to save money on satellites because of the Pentagon's large budget, but those funds could be redirected to incentivize companies with contracts to provide secure satellite bandwidth when needed.

"I would imagine if there are any concerns about satellite security and control they would be alleviated by the operator, because the military would be their preferred customer," he says.

An open question is whether or how the Pentagon will tap the services soon to be offered by the companies that propose to launch hundreds or even thousands of small communications satellites. These include OneWeb, a startup based in the Virginia suburbs of Washington, D.C., that plans to launch up to 700 satellites, and Boeing, which aims to launch 1,300 satellites within six years with the goal of expanding that constellation to 2,900. Both of these companies are contributing to the Air Force analysis of alternatives.

The Air Force is also seeking ways to improve its procurement of satellite bandwidth through a series of Pathfinder studies that began in 2014. Rebecca Cowen-Hirsch, who seeks government contracts for United Kingdom-based Inmarsat, which is also a participant in the analysis of alternatives, says she is frustrated by the slow progress of the Pathfinder studies and hopes the analysis of alternatives will encourage the Air Force to pool commercial and military bandwidth in one network.

"The challenges lie in cultural impediments rather than technological," she says. "Building additional WGS satellites would be pressing the easy button."

Loverro also wants the Air Force to take a leap and view commercial satellites as a full-time defense resource.

"No analysis will ever be able to prove what is fundamentally an economically uncertain prospect," Loverro says. "You have to go ahead and actually try it." ★

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Shaping the Future of Aerospace

A Soyuz rocket launches from the Baikonur Cosmodrome in Kazakhstan.
NASA

Kazakhstan Journal

The former Soviet republic faces some daunting economic challenges, due partly to the effects of sanctions on its trading partner, Russia. On a July visit, former Pentagon official Amanda Simpson found a country determined to carve a place for itself among the world-leading aerospace nations.

By Amanda Simpson

Which country hosts the most human space launches and recoveries? As surprising as it might be, the answer is the Republic of Kazakhstan in Central Asia. The country that takes pride as the region where horses were domesticated five thousand years ago now has aspirations to soar ahead in the aerospace field, far beyond its leasing of the Baikonur Cosmodrome launch complex to neighboring Russia and providing its northern steppes as a landing zone for returning Soyuz capsules.

Starting from the remains of a superpower has been and will continue to be a technical and economic challenge. Kazakhstan is undertaking this post-Soviet modernizing without distancing itself from that Soviet heritage. Kazakhstan, in fact, held onto its status as a Soviet Socialist Republic until just 10 days before the Soviet Union disbanded in December 1991. President Nursultan Nazarbayev was picked by the Soviet Union in 1989 to lead the Communist Party in Kazakhstan, elected president after independence and most recently re-elected in 2015 with almost 98 percent of the vote, according to news accounts.

I visited Kazakhstan in late July as a guest of the U.S. Embassy. I was there to participate in forums organized around the future energy-themed Expo 2017 being held in the capital city of Astana. As a recognized expert in the operational reliability of energy systems and use of large renewable energy projects, I attended meetings the embassy arranged to advise Kazakhstan government and industry leadership. I also have experience in aerospace and my remaining schedule was filled with meetings with members of the aerospace sector. I was struck by the country's determination to expand its space enterprises as part of its post-Soviet-era modernization.

Kazakhstan owns two telecommunications satellites and controls its two Earth observation satellites, all of which were built by European companies. The national space company, Kazakhstan Gharysh Sapary or KGS for short, is developing a complex for indigenous satellite design, construction and testing. KGS is also installing a ground station for a differential navigation system that will receive and analyze signals from the U.S. GPS constellation, the European Galileo satellites and the Russian GLONASS (Global Navigation Satellite System) spacecraft, and transmit accuracy corrections nationwide. KGS also plans to build on its astrophysical experience to produce aerospace materials that can meet U.S. and European standards. It plans to build a defense industry around armored vehicles, munitions and high-altitude unmanned air vehicles.

Kazakhstan's plans in space

Like all space-faring nations, Kazakhstan has learned to persevere in the face of failures. Control of the country's first communications satellite, KazSat-1, built by Moscow-based Khrunichev Space Center in cooperation with Thales Alenia Space and launched in mid-2006, was lost in mid-2008, according to news reports. The next two spacecraft, KazSat-2 and KazSat-3 (launched in 2011 and 2014), are providing telecommunications, television broadcasting and high-speed internet access in Kazakhstan and its neighboring countries.

I had an opportunity to meet with the KGS leadership, including president Yergazy Nurgalyev. He discussed the company's plans for long-term industrial programs in the field of space activity, and he presented plans for establishing the complex in Astana for satellite design, assembly and testing. Already operating at the complex is a control center for the two Earth observation satellites in orbit. KazEOSat-1 and KazEOSat-2 are multispectral imaging spacecraft built by what was then known as EADS Astrium, now part of Astrium Defence and Space. KazEOSat-1 provides 1-meter resolution imagery and KazEOSat-2 provides 6-meter resolution. Islam Sakirov, the lead specialist at the KGS International Cooperation Office, explained that while the citizens and customers in Kazakhstan have first rights to decide where these satellites point their cameras, the country has partner agreements for imagery distribution with 10 other countries that fall under the orbits. Additionally, imagery from other areas along the orbital track is available for purchase from KGS. Data is disseminated within Kazakhstan for monitoring agricultural, geological and mineral resources as well as natural hazards. KGS indicated that the Kazakhstan government has an interest in building a National Spatial Digital Infrastructure and reaching out to the region to

▼ **The author, right,** meets with former cosmonaut Aidyn Aimbetov of Kazakhstan and tries on one of the gloves he wore in the Soyuz capsule while traveling to the International Space Station.

Courtesy photo Amanda Simpson

ISILaunch Services

▲ **Students at the Al-Farabi** Kazakh National University in Almaty built the Al-Farabi-1 cubesat, which was launched in February 2017.

I was struck by the country's determination to expand its space enterprises as part of its post-Soviet-era modernization.

encourage the same.

KGS and the U.S. Geological Survey have also teamed up at times. In 2015, they co-hosted a regional Central Asia workshop on Earth Remote Sensing as applied to integrated water resource management. This workshop highlighted KGS' ambition to become a regional center for remote sensing. USGS has also helped KGS calibrate sensors on the KazEOSats and is advising on the development of Kazakhstan's National Spatial Data Infrastructure.

KGS is finishing development of the differential navigation stations, and plans to expand the system to include China's Compass satellite system, said cosmonaut and Kazakhstan national hero Aidyn Aimbetov, KGS vice president for space technology. There will be numerous local stations, plus a high-power shore-based marine station deployed to cover the Caspian Sea.

Kazakhstan's first indigenously produced satellite was launched in February from India. Al-Farabi-1 is a 2-unit cubesat built by students at the Al-Farabi Kazakh National University in Almaty. The 10-by-10-by-20-centimeter satellite is the product of an educational mission to develop and test components manufactured in Kazakhstan. The National Center for Space Research and Technology has produced a 3U cubesat to study the Earth's magnetic field. This vehicle was designed and built without any foreign assistance and is scheduled for launch atop a Falcon 9 in February 2018, according to Marat Ismailov, director of the national center's Material Science and Space Instrumentation Department. The center also is working with KGS to develop a radar imaging satellite to complement the nation's electro-optical spacecraft. This vehicle is targeted for launch in 2024.

At Kazakhstan's largest city, Almaty, I met with the center's leadership. They outlined some of their ambitious plans to advance the country's aerospace and defense industry. Center president Chingis Omarov explained that to spur investment and international cooperation, his organization is focusing on supporting the design and development of armored vehicles, munitions and unmanned air vehicles. The initial challenge will be to replace the Soviet-era machine tools and equipment still in use throughout the country. Ismailov has a goal of creating products that meet U.S. and European standards. His current emphasis is on carbon plastics and insulating films. Assylkhan Bibossinov, director of the Aerospace and Astrophysical Institute, sees solar powered air vehicles as more versatile than satellites. With 30 percent to 40 percent efficient panels and batteries that come in at 400 watts per kilogram, he anticipates that Kazakhstan industry can develop an aircraft that can operate for months or years at altitudes of about 100,000 feet.

The future of the Baikonur Cosmodrome also seems secure. Kazakhstan and Russia started the Baiterek Project in 2004 as a joint venture to modernize the facility and assure continued use through 2050. The project includes modifying Kazakhstan-owned and -operated launch facilities starting in 2018 for the new Phoenix carrier rocket to be launched beginning in 2025, and expansion of joint operations at the Proton and other launch facilities.

NASA

A **Soyuz rocket** is rolled out by train to the launch pad at the Baikonur Cosmodrome in Kazakhstan.

While Russia says it plans to launch from the Vostochny Cosmodrome within its own borders, construction issues and financial restrictions continue to delay completion. Even so, Russian reliance on Baikonur will keep Kazakhstan involved in launch operations for many decades to come.

Inhibiting nuclear proliferation

After the Soviet Union broke up, Kazakhstan temporarily inherited the nuclear weapons and facilities in its territory. This, for a time, made it the fourth largest nuclear power and owner of the Semipalatinsk Test Site, where the Soviet Union conducted 456 nuclear explosions between 1949 and 1989. In 1994, a covert operation by the governments of Kazakhstan and the United States dismantled the nuclear weapons, removed materials and closed the test site. Project Sapphire, as it is known, secured and removed 600 kilograms of weapons-grade enriched uranium that was stored in Kazakhstan to fuel Russian Alfa class submarines. The U.S. and allies in Europe and Asia created the intergovernmental International Science and Technology Center in Kazakhstan to employ Russian nuclear engineers and scientists and inhibit proliferation of their knowledge. Today, this center pursues seismic and radiological research along with bio-security, water-security, and other chemical, biological, radiological, and nuclear transportation safety and security issues, said David Cleave, the executive director. This research is primarily funded by the U.S. Department of Energy and the European Union. These projects are serving as pathfinders and are leading to similar efforts throughout Central Asia to employ ex-Soviet engineers.

Fiscal challenges

Kazakhstan is rich in resources that are the engine of its economy. It is the world's leading exporter of uranium. Crude oil and natural gas are exported to Russia and the eastern portions of Europe, accounting for 20 percent of its gross domestic product, 50 percent of its revenue and 60 percent of its exports. But the protracted decline in global oil prices has severely impacted the funds available to support industrial and aerospace development. The World Bank reports that Kazakhstan saw a 4.1 percent decrease in its gross domestic product in 2014 and further decreases in 2015 and 2016. Low oil prices and sanctions against the country's largest trading partner, Russia, impacted exports, which fell 40 percent in the first half of 2015. This had a direct effect on the currency, which devalued 26 percent in 2015 after falling 19 percent in 2014. Today, inflation stands at an average rate of 14.6 percent. However, with an anticipated increase in crude oil prices over the next few years and increased production with new fields coming on line, the Kazakhstan economy is expected to grow by as much as 2.9 percent per year over the next three years.

It takes a lot for an economy to transform itself from a supplier of raw materials to an exporter of ideas, science, and technological advancement. The people of Kazakhstan are proud of their achievements in space with large sections of their National Museum and Expo pavilion celebrating past successes and prospective opportunities. Their government and industry stand committed to making space a large part of their future. I wish them well. ★

Amanda Simpson
was U.S. deputy assistant secretary of defense for operational energy from September 2015 to January 2017, and worked in the aerospace and defense industries for 35 years as a program manager and test pilot. She is an AIAA associate fellow.

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AIAA Bulletin

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

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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.

Calendar

Notes About the Calendar

For more information on meetings listed below, visit our website at www.aiaa.org/events or call 800.639.AIAA or 703.264.7500 (outside U.S.).

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2017			
13–15 Nov†	1st International Academy of Astronautics (IAA) Conference on Space Situational Awareness	Orlando, FL (www.icssa2017.com)	
16 Nov	DirectTech Webinar—Applications of Model-Based Systems Engineering	Virtual (www.aiaa.org/onlinelearning)	
4–8 Dec†	Flight Software Workshop	Laurel, MD (www.flightsoftware.org)	28 Aug 17
7 Dec	DirectTech Webinar—Materials for Hypersonic Vehicles	Virtual (www.aiaa.org/onlinelearning)	
14 Dec	DirectTech Webinar—Structures for Hypersonic Vehicles	Virtual (www.aiaa.org/onlinelearning)	
2018			
6–7 Jan	5th International Workshop on High-Order CFD Methods	Kissimmee, FL	
6–7 Jan	Future CFD Technologies Workshop: Bridging Mathematics and Computer Science for Advanced Aerospace Simulation Tools	Kissimmee, FL	
7 Jan	Space Standards and Architectures Workshop	Kissimmee, FL	
6–7 Jan	Aircraft and Rotorcraft System Identification Engineering Methods for Manned and UAV Applications with Hands-On Training Using CIFER® Course	Kissimmee, FL	
6–7 Jan	Large Eddy Simulation of Turbulent Combustion: Theory, Modeling and Practice Course	Kissimmee, FL	
6–7 Jan	Introduction to Software Engineering Course	Kissimmee, FL	
6–7 Jan	Stochastic Mechanics of Materials and Structures Course	Kissimmee, FL	
6–7 Jan	Missile Guidance Course	Kissimmee, FL	
7 Jan	Aeroelastic Wind Tunnel Testing and Aeroelasticity Considerations for Non-Aeroelastic Tests Course	Kissimmee, FL	
8 Jan	2018 Associate Fellows Recognition Ceremony and Dinner	Kissimmee, FL	
8–12 Jan	AIAA SciTech Forum (AIAA Science and Technology Forum and Exposition) Featuring: – AIAA/AHS Adaptive Structures Conference – AIAA Aerospace Sciences Meeting – AIAA Atmospheric Flight Mechanics Conference – AIAA Information Systems — Infotech@Aerospace Conference – AIAA Guidance, Navigation, and Control Conference – AIAA Modeling and Simulation Technologies Conference – AIAA Non-Deterministic Approaches Conference – AAS/AIAA Space Flight Mechanics Meeting – AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference – AIAA Spacecraft Structures Conference – Wind Energy Symposium	Kissimmee, FL	12 Jun 17
22–25 Jan †	64th Annual Reliability & Maintainability Symposium (RAMS)	Reno, NV (Contact: http://www.rams.org)	
21 Mar	AIAA Congressional Visits Day (CVD)	Washington, DC (www.aiaa.org/CVD)	
1 May	2018 Fellows Dinner	Crystal City, VA	
2 May	Aerospace Spotlight Awards Gala	Washington, DC	

†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.

AIAA Continuing Education offerings

AIAA Symposiums and Workshops

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
3–10 Mar †	IEEE Aerospace Conference	Big Sky, MT (Contact: www.aeroconf.org)	
8–10 May	AIAA DEFENSE Forum (AIAA Defense and Security Forum) Featuring: – AIAA Missile Sciences Conference – AIAA National Forum on Weapon System Effectivenss – AIAA Strategic and Tactical Missile Systems Conference	Laurel, MD	30 Nov 17
28–30 May †	25th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (Contact: www.elektropribor.spb.ru)	
28 May–1 Jun	SpaceOps 2018: 15th International Conference on Space Operations	Marseille, France (Contact: www.spaceops2018.org)	6 Jul 17
25–29 Jun	AIAA AVIATION Forum (AIAA Aviation and Aeronautics Forum and Exposition) Featuring: – AIAA/CEAS Aeroacoustics Conference – AIAA Aerodynamic Measurement Technology and Ground Testing Conference – AIAA Applied Aerodynamics Conference – AIAA Atmospheric Flight Mechanics Conference – AIAA Atmospheric and Space Environments Conference – AIAA Aviation Technology, Integration, and Operations Conference – AIAA Flight Testing Conference – AIAA Flow Control Conference – AIAA Fluid Dynamics Conference – AIAA/ASME Joint Thermophysics and Heat Transfer Conference – AIAA Modeling and Simulation Technologies Conference – AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference – AIAA Plasmadynamics and Lasers Conference	Atlanta, GA	9 Nov 17
25–29 Jun†	15th Spacecraft Charging Technology Conference (SCTC)	Kobe, Japan (Contact: http://www.org.kobe-u.ac.jp/15sctc/index.html)	
3–6 Jul†	ICNPAA-2018 - Mathematical Problems in Engineering, Aerospace and Sciences	Yerevan, Armenia (Contact: http://www.icnpaa.com)	
9–11 Jul	AIAA Propulsion and Energy Forum (AIAA Propulsion and Energy Forum and Exposition) Featuring: – AIAA/SAE/ASEE Joint Propulsion Conference – International Energy Conversion Engineering Conference	Cincinnati, OH	4 Jan 18
19–23 Aug†	2018 AAS/AIAA Astrodynamics Specialist Conference	Snowbird, UT (http://www.space-flight.org)	
17–19 Sep	AIAA SPACE Forum (AIAA Space and Astronautics Forum and Exposition) Featuring: – AIAA Complex Aerospace Systems Exchange	Orlando, FL	8 Feb 18
1–5 Oct†	69th International Astronautical Congress	Bremen, Germany	

AIAA Announces Class of 2018 Associate Fellows

AIAA is pleased to announce its Class of 2018 Associate Fellows. AIAA will formally honor and induct the class at its AIAA Associate Fellows Recognition Ceremony and Dinner on Monday, 8 January, at the Gaylord Palms in Kissimmee, FL, in conjunction with the 2018 AIAA SciTech Forum.

"The distinguished individuals comprising the Class of 2018 Associate Fellows exemplify extraordinary accomplishments and leadership in the global aerospace community," said AIAA President Jim Maser. "Each individual has demonstrated a remarkable commitment to furthering the advancement of aerospace science and technology, and each has performed important work that the Institute is proud to recognize. Their dedication, ingenuity, and accomplishments serve as an inspiration to current and future aerospace professionals. I look forward to helping honor their achievements at the 2018 AIAA SciTech Forum this January."

The grade of Associate Fellow recognizes individuals "who have accomplished or been in charge of important engineering or scientific work, or who have done original work of outstanding merit, or who have otherwise made outstanding contributions to the arts, sciences, or technology of aeronautics or astronautics." To be selected as an Associate Fellow an individual must be an AIAA Senior Member in good standing, with at least twelve years professional experience, and be recommended by a minimum of three current Associate Fellows.

The Class of 2018 AIAA Associate Fellows are:

Daniel R. Adamo, *Independent Astrodynamics Consultant*

Thomas C. Adang, *The Aerospace Corporation*

Srinivasan Arunajatesan, *Sandia National Laboratories*

Carl A. Avila, *The Boeing Company*

John S. Baras, *University of Maryland*

Arnold A. Barnes III, *Ball Aerospace & Technologies Corporation*

Thomas P. Barrera, *LIB – X Consulting*

Karen T. Berger, *NASA Langley Research Center*

Riccardo Bevilacqua, *University of Florida*

Nicholas J. Bisek, *Air Force Research Laboratory*

Agnes Blom – Schieber, *The Boeing Company*

Jeffrey C. Boulware, *U.S. Air Force*

David E. Bowles, *NASA Langley Research Center*

Aaron Michael Brandis, *AMA Inc. – NASA Ames Research Center*

Darren K. Brock, *Lockheed Martin Corporation*

Kerri Cahoy, *Massachusetts Institute of Technology*

Leanne Caret, *The Boeing Company*

David Casbeer, *Air Force Research Laboratory*

Seongim Choi, *Virginia Polytechnic Institute and State University*

Girish Chowdhary, *University of Illinois at Urbana – Champaign*

Helmut K. Ciezki, *German Aerospace Center – DLR*

Janet L. Convery, *General Electric Corporation*

William Paul Crisler, *Embry – Riddle Aeronautical University*

Juan R. Cruz, *NASA Langley Research Center*

Angela S. Diggs, *Air Force Research Laboratory*

Tomasz G. Drozda, *NASA Langley Research Center*

John W. Elbon, *The Boeing Company*

Frode Engelsen, *The Boeing Company*

Mark E. Ewing, *Orbital ATK*

Martin Frederick, *Northrop Grumman Corporation*

Sheree Gay, *U.S. Department of Defense*

Lie – Mine Gea, *The Boeing Company*

Edward Gerding, *The Boeing Company*

Amir S. Gohardani, *International Rectifier HiRel Products – An Infineon Technologies Company*

Vinay K. Goyal, *The Aerospace Corporation*

Clinton P. Groth, *University of Toronto*

Steven G. Hagerott, *Textron Aviation*

Raymond J. Harvey, *Johns Hopkins University Applied Physics Laboratory*

David P. Hills, *Airbus Americas Inc.*

Frank Hoffmann, *Scott's – Bell 47, Inc.*

Greg N. Holt, *NASA Johnson Space Center*

Naveed Hussain, *The Boeing Company*

Matthew G. Hutchison, *Aurora Flight Sciences Corporation*

Monica A. Jacinto, *Aerojet Rocketdyne*

William C. Jackson, *Sierra Nevada Corporation*

Prakash Chand Jain, *Defense Research & Development Laboratory*

Keith L. Jenkins, *Keith L. Jenkins, Registered Patent Attorney, LLC*

Dexter Johnson, *NASA Glenn Research Center*

Eric N. Johnson, *Pennsylvania State University*

Narendra Digamber Joshi, *General Electric Corporation*

Jiro Kasahara, *Nagoya University*

Wallace E. Kirkpatrick, *DESE Research, Inc.*

William L. Kleb, *NASA Langley Research Center*

Jeff R. Kloos, *GE Aviation*

Bernard F. Kutter, *United Launch Alliance*

Andrew W. Lewin, *Orbital ATK*

Renfu Li, *Huazhong University of Science and Technology*

Taylor C. Lilly, *Lockheed Martin Corporation*

Gretchen M. Lindsay, *The Aerospace Corporation*

Jonathan S. Litt, *NASA Glenn Research Center*

Yongming Liu, *Arizona State University*

Thomas Lombaerts, *NASA Ames Research Center*

Enrico Lorenzini, *University of Padova*

Youssef M. Marzouk, *Massachusetts Institute of Technology*

John F. Matlik, *Rolls – Royce Corporation*

Stephen T. McClain, *Baylor University*

Chris C. McCormick, *PlanetiQ / Global Weather & Climate Solutions*

Jay McMahon, *University of Colorado Boulder*

Mehran Mesbahi, *University of Washington*

Jeffrey M. Michlitsch, *The Aerospace Corporation*

Philip T. Mongan, *ARES Corporation*

Susana Muñoz, *Kratos Defense & Security Solutions, Inc.*

Peter Gervase Nicholson, *Warp Ten Solutions Pty Ltd*

Paul W. Niewald, *The Boeing Company*

Michael A. O'Hara, *Ball Aerospace & Technologies Corporation*

Robin J. Osborne, *ERC, Inc./Jacobs – ESSSA Group – NASA Marshall Space Flight Center*

Michael A. Park, *NASA Langley Research Center*

James Parsons, *Dynetics, Inc.*

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Jinjun Shan, *York University*

Anupam Sharma, *Iowa State University*

Sang Joon Shin, *Seoul National University*

Steve Snyder, *California Institute of Technology Jet Propulsion Laboratory*

Steven F. Son, *Purdue University*

Zahra Sotoudeh, *California State Polytechnic University, Pomona*

John T. Spyropoulos, *Naval Air Systems Command (NAVAIR)*

J. Scott Stadler, *MIT Lincoln Laboratory*

Kelly A. Stephani, *University of Illinois at Urbana – Champaign*

Tom G. Stoumbos, *Orbital ATK*

Angela Suplisson, *U.S. Air Force Academy*

Sean Shan – Min Swei, *NASA Ames Research Center*

Roger W. Teague, *Assistant Secretary (Acquisition), U.S. Air Force*

Karen A. Thole, *Pennsylvania State University*

Russell H. Thomas, *NASA Langley Research Center*

John Tylko, *Aurora Flight Sciences Corporation*

Subith Vasu, *University of Central Florida*

Miroslav N. Velev, *Aries Design Automation, LLC*

Sally A. Viken, *NASA Langley Research Center*

Qiqi Wang, *Massachusetts Institute of Technology*

Michael M. Watkins, *California Institute of Technology Jet Propulsion Laboratory*

David J. Weeks, *Radiance Technologies*

Gary L. Wentz Jr., *United Launch Alliance*

Eliot Winer, *Iowa State University*

David Wing, *NASA Langley Research Center*

Chad Winkler, *The Boeing Company*

Michael Winter, *Pratt & Whitney, United Technologies Corporation*

Serhiy Yarusevych, *University of Waterloo*

James V. Zappa, *Moog, Inc.*

Olesya I. Zhupanska, *University of Arizona*

AIAA Associate Fellows Recognition Ceremony and Dinner

Celebrate the Class of 2018 AIAA Associate Fellows

Monday, 8 January 2018

Join us as we recognize exemplary professionals for their accomplishments in engineering or scientific work, outstanding merit, and contributions to the art, science, or technology of aeronautics or astronautics.

The Class of 2018 AIAA Associate Fellows will be officially recognized during the Associate Fellows Recognition Ceremony and Dinner, to be held in conjunction with the 2018 AIAA SciTech Forum at the Gaylord Palms in Kissimmee, Florida, on Monday evening, 8 January 2018.

Please support your colleagues, and join us for the induction of the Class of 2018 AIAA Associate Fellows. Tickets to this celebrated event are available on a first-come, first-served basis and can be purchased for $100 via the 2018 AIAA SciTech Forum registration form, 2018 Associate Fellows Dinner event registration form, or onsite (based on availability).

For more information and to register online, please visit www.aiaa.org/AssociateFellowsDinner2018

AIAA
Shaping the Future of Aerospace

News

AIAA Participates in International Space Event

The International Astronautical Congress (IAC) is the premier annual event of the International Astronautical Federation (IAF) and its partner organizations, the International Academy of Astronautics (IAA) and the International Institute of Space Law (IISL). The event brings together thousands of decision makers from across all sectors of the global space industry to discuss the latest space discoveries and developments, as well as explore opportunities to partner and collaborate. Many AIAA members participate in the IAC, and some are active on the committees that comprise the IAF, IAA, and IISL.

Hosted 25–29 September by the Space Industry Association of Australia in Adelaide, Australia, this year's Congress included plenary sessions highlighting the ongoing activities and advances of the world's leading space agencies, as well as a discussion on the social and economic impacts of space exploration; space traffic management; exploration systems research and development; on-orbit satellite servicing and refueling; and international cooperation in lunar space exploration. With over 4,200 delegates, IAC 2017 provided an excellent opportunity to engage across the international space community.

The AIAA delegation at IAC 2017 focused its efforts on engaging with its existing partners, while also exploring opportunities for further collaboration with new organizations and IAF members. To this end, AIAA Executive Director Sandy Magnus met with representatives from the United Nations Office for Outer Space Affairs and the Chinese Society of Astronautics to discuss collaboration opportunities. IAC 2017 also provided AIAA with an opportunity to promote IAC 2019, which will be held in Washington, D.C., in October 2019. In addition, AIAA hosted a members' reception on the Sunday prior to the Congress start to bring together AIAA members from across the globe and provide them with an informal opportunity to interact with the AIAA delegation and each other, and learn more about AIAA's progress in planning IAC 2019. AIAA also sponsored a Young Professionals event during IAC 2017, where Magnus gave opening remarks encouraging students and young professionals to continue engaging in their passions and the space community at large.

For more information about the IAC, including instructions for submitting a paper to present at IAC 2018 in Bremen, Germany, please visit: http://www.iafastro.org/events/iac/.

To learn more about IAC 2019 in Washington, D.C., please visit: http://www.iac2019.org.

Zarem Award for Distinguished Achievement in Astronautics

Langston Williams from Auburn University, Auburn, AL, has won the 2017 AIAA Foundation Abe M. Zarem Award for Distinguished Achievement in Astronautics. The award recognizes graduate students in aeronautics or astronautics who have demonstrated outstanding scholarship in their field. The award honors Williams for his paper "Development of the Bidirectional Vortex in a Hemispherically-Shaped Rocket Engine." Williams travelled to Australia to participate in the student paper competition at the 68th International Astronautical Congress in September.

The Zarem award also recognizes the faculty advisor of the award winner, reflecting Dr. Zarem's belief that the guidance of faculty members is fundamental to the success of student research. **Dr. Joseph Majdalani**, professor of Aerospace Engineering at Auburn University, will receive a certificate of recognition for his work with Williams. Dr. Majdalani is the first faculty member to be recognized by the Abe Zarem panel twice for his role in advising graduate students.

"I am absolutely thrilled at the news of being selected for the prestigious Abe M. Zarem Award for Distinguished Achievement in Astronautics! … My advisor, Dr. Joseph Majdalani, is equally excited about his receipt of the Abe Zarem Educator of the Year title. He has been an outstanding mentor to me every step of the way," said Williams.

He will be recognized with the Abe M. Zarem Medallion in Astronautics at the AIAA SciTech Forum in January.

IMPORTANT ANNOUNCEMENT: New Editor-in-Chief Sought for the *Journal of Aerospace Information Systems*

AIAA is seeking an outstanding candidate with an international reputation for this position to assume the responsibilities of Editor-in-Chief of the *Journal of Aerospace Information Systems* in early 2018.

The Editor-in-Chief is responsible for maintaining and enhancing the journal's quality and reputation as well as establishing a strategic vision for the journal. He or she receives manuscripts, assigns them to Associate Editors for review and evaluation, and monitors the performance of the Associate Editors to ensure that the manuscripts are processed in a fair and timely manner. The Editor-in-Chief works closely with AIAA Headquarters staff on both general procedures and the scheduling of specific issues for this online-only journal. Detailed record keeping and prompt actions are required. AIAA provides a small honorarium and all appropriate resources to support the manuscript review process, including a web-based manuscript-tracking system.

Interested candidates are invited to submit resumes and letters of application for consideration. A selection committee will seek candidates and review all applications received. A final recommendation will be made to the AIAA Board of Trustees for approval. This is an open process, and the final selection will be made only on the basis of the applicants' merits. All candidates will be notified of the final decision. Questions may be referred to Heather Brennan, Director, Publications at **heatherb@aiaa.org**.

Applications are due **1 December 2017**. The full journal scope and complete application requirements will be available in Aerospace Research Central on the landing page for *Journal of Aerospace Information*

2018 AIAA Sustained Service Award Winners Announced

Congratulations to the following AIAA members who will receive the AIAA Sustained Service Award. Without their passion for aerospace engineering and science as well as their dedicated efforts, AIAA could not fulfill our mission to inspire and advance the future of aerospace.

Bob Greene
Vice President
Aeronaut Corporation
McCaysville, Georgia

"For dedication and tireless efforts over 20 years of continuous service to the Atlanta Section as Programs Chair, CVD state team Captain, Section Chair and officer, and STEM programs promoter."

Laurence D. Leavitt
Chief Scientist (retired)
NASA Langley Research Center
Hampton, Virginia

"For sustained, significant service over 42 years across local, regional, and national levels with emphasis on technical committees, outreach, and recognition of deserving colleagues."

Robert A. Stuever
Senior Specialist Engineer
Textron Aviation
Andalem, Kansas

"For sustained service to the Institute at both the national and section levels with a variety of roles and responsibilities."

The Sustained Service Award recognizes an AIAA member who has shown continuing dedication to the interests of the Institute by making significant and sustained contributions over a period of time, typically 10 years or more. Please visit AIAA Sustained Service Award (https://www.aiaa.org/HonorsAndAwardsRecipientsList.aspx?awardId=986b74ec-3f4d-44f3-b1ad-6aa0e9e7f400) for further information about this award and to download the nomination form. The 2019 Sustained Service Award deadline is **1 July 2018**.

AIAA New England Section Diversity Event

The AIAA Diversity and Inclusion Plan was published during summer 2016. The plan specifically calls for participation, advocacy and support from the local levels of regions, sections and chapters. Specific objectives include conducting events, identifying and disseminating best practices for attracting and retaining diverse AIAA members, mentoring programs for diverse members, and supporting Institute efforts to address poor retention of student members after graduation. The AIAA New England Section has taken up this initiative aggressively and has been actively working toward reaching out to our ~1000 section members, planning and hosting special events, as well as collaborating with other organizations and professional societies.

Our most recent event took place on 14 September at the MIT campus where 72 attendees heard a talk by Professor Sheila Widnall entitled "The Next Step for Women in Engineering—Transition from University to Industry." Professor Widnall, a past AIAA President, a past Secretary of the Air Force and currently an Institute Professor and Professor of Aeronautics and Astronautics at MIT is co-chair of a committee at NAE/NAS/NAM on Addressing Sexual Harassment in Science, Engineering, and Medical Workplaces. Although women comprise 20% of engineering graduates, only 11% are practicing engineers. Women are leaving engineering. To understand why, recent studies have focused on the quality of their first experiences as working engineers. The studies show that leadership and organizational qualities of first-line managers as well as organizational climate are of significant importance. This is clearly something that organizations can and should focus on. It will produce a more accepting environment for all new engineering employees and aid the company as well.

ABOVE: The audience beginning to assemble.

ABOVE: From left, Joseph Poirier, AIAA member and chair of Boston ASME who advertised the event to ASME members; Rick Coveno, Chair of the SAE New England Section who publicized the event to SAE members; Raul Rios, participant from Lincoln Laboratory who helped organize the event; Dr. Hsiao-hua Burke, AIAA Fellow and Diversity Working Group member who helped organize the September 2016 and 2017 events; Professor Sheila Widnall, who gave the presentation; and Jeffrey Mobed, AIAA New England Chair.

Professor Widnall discussed recommendations being evaluated, including investing in providing substantial training and professional development, taking simple steps in terms of defining and clarifying what is expected of the employees and creating a culture that respects all by rooting out uncivil and undermining behaviors in the workplace. Attendees were very engaged as evidenced by the many in-depth questions and discussion followed by the presentation.

Not only the event was well attended, the attendees represented a healthy spectrum of participants of young students (undergraduate and graduate), young professionals, and established professionals from engineering and management ranks. Another noteworthy accomplishment of this event is the collaboration established by the AIAA New England Section with MIT campus, the American Society of Mechanical Engineers, the SAE, and the American Helicopter Society.

CALL FOR NOMINATIONS

AIAA Foundation Award for Excellence

The AIAA Foundation Award for Excellence is the highest award presented by the AIAA Foundation Board of Trustees, recognizing excellence within the aerospace community. Eligible nominees will offer a unique achievement or extraordinary lifetime contributions inspiring the global aerospace community.

Nomination Deadline: 15 January 2018

For more information or to make a nomination, please visit **http://www.aiaa.org/FoundationAwardForExcellence/.**

Obituary

AIAA Associate Fellow Snyder Died in September

James "Jim" R. Snyder Sr., age 79, passed away on 18 September. He was 79 years old.

Mr. Snyder excelled in the aerospace field for almost 60 years and was doing the work that he loved to the end of his life. He began his career at Wright-Patterson Air Force Base in 1958 as a Co-operative Program student from the University of Cincinnati. After retiring from the base, he continued to support the Air Force as a consultant and contractor. He was a one of a kind aerodynamicist, aircraft designer and analyst. He made many important advanced research contributions to the United States Air Force, NASA and DARPA. He contributed to the design and development specifications for the Air Force Air Launched Cruise Missile (ALCM) AGM-68, the B-1 bomber, the F-15 and F-16 fighters, and the C-17 transport.

During his career, Snyder made innovative contributions to aircraft for high altitude reconnaissance, quiet operations, long endurance, hypersonic flight and special operations. He did advanced research in the areas of aircraft aerodynamic optimization, aero-propulsion integration, and stability and control. Snyder did extensive aircraft design and propulsion integration research to show the benefits to fighter and transport aircraft of new engine technology over existing propulsion technology. He developed advanced aircraft configurations for many different applications. Weapons work included missile flight path control and guidance, missile fluidic stability and control and acoustics.

Mr. Snyder was an active member of AIAA. He authored many technical papers. Giving freely of his time, he was an advisor to the University of Cincinnati Department of Aerospace Engineering. He tutored students in mathematics and science and participated in STEM activities. He was the recipient of two Certificates of Recognition from NASA, the Affiliate Societies Council of Dayton Technical Leadership Award and the Department of the Air Force Outstanding Career Civilian Service Award.

AIAA Associate Fellow Holley Died in October

William E. Holley died on 5 October.

Holley received his Ph.D. from Stanford University in 1975, and became a distinguished engineer who advanced the growth of wind power worldwide. His career included time at Oregon State University as a professor, and most recently, he was a chief consulting engineer at General Electric.

He was also an inventor with multiple patents, a published author of technical literature, and was instrumental in the development of international industry standards.

Nominate Your Peers and Colleagues!

Do you know someone who has made notable contributions to aerospace arts, sciences, or technology? Bolster the reputation and respect of an outstanding peer—throughout the industry
Nominate them now!

Candidates for SENIOR MEMBER

- Accepting online nominations monthly

Candidates for ASSOCIATE FELLOW

- Acceptance Period begins 15 December 2017
- Nomination Forms are due 15 April 2018
- Reference Forms are due 15 May 2018

Candidates for FELLOW

- Acceptance Period begins 1 April 2018
- Nomination Forms are due 15 June 2018
- Reference Forms are due 15 July 2018

Candidates for HONORARY FELLOW

- Acceptance period begins 1 January 2018
- Nomination forms are due 15 June 2018
- Reference forms are due 15 July 2018

"Appreciation can make a day – even change a life. Your willingness to put it into words is all that is necessary."
– Margaret Cousins

For more information on nominations: aiaa.org/Honors

AIAA
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2017 Best Professional and Student Technical Papers

AIAA Technical Committees (TC) selected the best professional and student technical papers presented at the 2016–2017 AIAA forums. With a standard award criterion and selection process from their respective TCs, these authors were selected and presented with a Certificate of Merit at the forums. All Best Papers are tagged as "Best Paper" in AIAA's Aerospace Research Central (ARC).

BEST PROFESSIONAL AND STUDENT TECHNICAL PAPERS

AIAA Aerodynamic Measurement Technology Best Paper
AIAA 2017-1408, "Quantitative 2D Temperature Imaging in Turbulent Nonpremixed Jet Flames Using Filtered Rayleigh Scattering," Thomas McManus and Jeffrey Sutton, Ohio State University.

AIAA Aerospace Power Systems Best Paper
AIAA 2016-4520, "Solar Array Design for the Mars InSight Lander Mission," Giang Q. Lam, Scott A. Billets, Timothy A. Norick, and Richard W. Warwick, Lockheed Martin Space Systems Company.

AIAA Aerospace Power Systems Best Student Paper
- AIAA 2015-4246, "Experiment Design for Measuring Accommodation Coefficients for Modeling of Long-Duration Spaceflight Cryogenic Propellants," Samantha J. Alberts, Steven H Collicott, Praveen Srikanth, and Stephen D Heister, Purdue University.
- AIAA 2016-4522, "Fundamental Studies of Radio-Frequency Preionization for Frozen Inert Gas Plasma Magnetohydrodynamic Electric Power Generation," M. Tanaka, Y. Hitotsubashi, and Y. Okuno, Tokyo Institute of Technology.

AIAA Aircraft Design Best Paper
AIAA 2016-3765, "Design Studies of Thin-Haul Commuter Aircraft with Distributed Electric Propulsion," Alex Stoll and Gregor Veble Mikic, Joby Aviation.

AIAA Applied Aerodynamics Best Paper
AIAA 2016-4166, "Dynamic Stall Simulations on a Pitching Finite Wing," Kurt Kaufmann, Christoph Merz, and Anthony Gardner, DLR.

AIAA Atmospheric Flight Mechanics Best Paper
- AIAA 2016-3852, "Aerodynamic Modeling, System Identification and Analysis of Iced Aircraft Configurations," Christoph Deiler, DLR- German Aerospace Center.
- AIAA 2017-1398, "Handling Qualities Flight Test Assessment of a Business Jet NzU P-Fly-By-Wire Control System," Tom Berger and Mark Tischler, U. S. Army Aviation Development Directorate; Steven Hagerott, Textron Aviation; M. Christopher Cotting, James Cresham, Justin George, Kyle Krogh, Alessandro D'Argenio and Justin Howland, USAF Test Pilot School.

AIAA Collier Research Hypersizer/AIAA Structures Best Paper
AIAA 2016-0733, "Effect of Notch on the Failure Response of Oxide/Oxide Ceramic Composites," Dianyun Zhang, University of Connecticut; Pascal Meyer, University of Michigan; and Anthony Waas, University of Washington.

AIAA Electric Propulsion Best Paper
AIAA 2016-4839, "Mechanisms for Pole Piece Erosion in a 6-kW Magnetically-Shielded Hall Thruster," Ben Jorns, University of Michigan; Chris Dodson, UCLA, John Anderson, Jet Propulsion Laboratory; Dan Goebel, Jet Propulsion Laboratory; and Richard Hofer, Jet Propulsion Laboratory.

AIAA Energetic Components and Systems Best Paper
AIAA 2016-4932, "Thermal-Mechanical Characterization of Bridgewires and Surrounding Materials Utilizing Thermal Transient Testing," Charles J. Moore, Jennifer G. Morgan, and Luke B. Roberson, NASA Kennedy Space Center; Joseph Carney, University of Florida-Gainesville; Jarrod T. Whittaker, a.i.Solutions, Inc.; and John D. Glass, Vencore.

AIAA Flow Control Conference Best Paper
AIAA 2016-4081, "Aerodynamic Flow Control of Wake Dynamics Coupled to a Moving Bluff Body," Thomas J. Lambert, Bojan Vukasinovic, and Ari Glezer, Georgia Institute of Technology.

AIAA Flow Control Best Student Paper
AIAA 2016-3931, "The Influence of the Spatial Frequency Content of Discrete Roughness Distributions on the Development of the Crossflow Instability," Evelien van Bokhorst, Marco Placidi, and Christopher J. Atkin, University of London.

AIAA Gas Turbine Engines Best Paper
AIAA 2016-4647, "Investigation of Differences in Lean Blowout of Liquid Single-Component Fuels in a Gas Turbine Model Combustor," J. Grohmann, B. Rauch, T. Kathrotia, W. Meier, and M. Aigner, German Aerospace Center (DLR).

AIAA Guidance, Navigation and Control Best Paper
AIAA 2016-2099, "Stability Augmentation and Active Flutter Suppression of a Flexible Flying-Wing Drone," David K. Schmidt, University of Colorado-Colorado Springs.

AIAA High Speed Air Breathing Propulsion Best Paper
AIAA 2017-1538, "The Effect of Pulsed Injection on the Entrainment into a Cavity Based Flameholder in Supersonic Flow," Leslie A. Smith and Timothy Ombrello, Air Force Research Laboratory; and N. Sebastian Okhovat, Innovative Scientific Solutions, Inc.

AIAA Hybrid Rockets Best Paper
AIAA 2016-4562, "Vortex Combustion in a Lab-Scale Hybrid Rocket Motor," Christian Paravan, Jakub Glowacki, Stefania Carlotti, Filippo Maggi, and Luciano Galfetti, Technical University of Milan.

AIAA Hybrid Rockets Best Student Paper
AIAA 2016-4752, "Experimental and Analytical Investigation of Effect of Pressure on Regression Rate of Axial-Injection End-Burning Hybrid Rockets," Yuji Saito, Toshiki Yokoi, Harunori Nagata, Tsuyoshi Totania and Masashi Wakita, Hokkaido University; Hiroyuki Yasukochi and Kentaro Soeda, University of Tokyo.

AIAA Inlets, Nozzles, and Propulsion Systems Integration Best Paper
AIAA 2016-4800, "Installed Performance Assessment of a Boundary Layer Ingesting Distributed Propulsion System at Design Point," C. Goldberg, D. Nalianda, D. MacManus, and P. Pilidis, Cranfield University; and J. Felder, NASA Glenn Research Center.

AIAA Intelligent Systems Best Paper
AIAA 2016-2133, "Review of Proactive Safety Metrics for Rotorcraft Operations and Improvements Using Model-Based Parameter Synthesis and Data Fusion," Alexia Payan, Alek Gavrilovski, Hernando Jimenez, and Dimitri Mavris, Georgia Institute of Technology.

AIAA Liquid Propulsion Best Paper
AIAA 2016-4582, "Experimental Investigation of Continuous Detonation Rocket Engines for In-Space Propulsion," Richard Smith, GHKN Engineering, LLC; and Steven Stanley, Aerojet Rocketdyne.

Modeling and Simulation Technologies Best Paper

- AIAA 2016-1180, "Development of Spatial Disorientation Demonstration Scenarios for Commercial Pilot Training," David H. Klyde, Amanda Lampton, and Philip Schultze, Systems Technologies, Inc.
- AIAA 2016-4299, "Objective ARX Model Order Selection for Multi-Channel Human Operator Identification," Nicole Roggenkämper, Daan Pool, Frank M. Drop, Marinus M. van Paassen, and Max Mulder, Delft Technical University.

AIAA Nuclear and Future Flight Propulsion Best Paper
AIAA 2016-4887, "Comparing Low Enriched Fuel to Highly Enriched Fuel for use in Nuclear Thermal Propulsion Systems," Vishal K. Patel, Michael J. Eades, and Paolo F. Venneri, Ultra Safe Nuclear Corp.; and Claude R. Joyner II, Aerojet Rocketdyne.

AIAA Plasmadynamics and Lasers Best Paper

- AIAA 2016-3531, "LES/RANS Modeling of Aero-Optical Effects in a Supersonic Cavity Flow," Ilya A Zilberter and Jack R. Edwards, North Carolina State University.
- AIAA 2017-1584, "OH Radical Measurements in Hydrogen-Air Mixtures at the Conditions of Strong Vibrational Nonequilibrium," Caroline Winters, Yi-Chen Hung, Elijah Jans, Kraig Frederickson, and Igor Adamovich, Ohio State University.

AIAA Propellants and Combustion Best Paper
AIAA 2016-1454, "Experimental Assessment of Premixed Flames Subjected to Extreme Turbulence," Aaron W. Skiba, Timothy M. Wabel, Jacob E. Temme, James F. Driscoll, University of Michigan.

AIAA Solid Rockets Best Paper
AIAA 2016-4793, "Motor Scale and Propellant Geometry Effects on Pressure Oscillations in Aft-Finocyl Solid Rocket Motors," Enrico Cavallini and Bernardo Favini, Università degli Studi di Roma "La Sapienza"; and Agostino Neri, European Space Agency.

AIAA Solid Rockets Best Student Paper
AIAA 2016-4701, "Local Linear Stability Analysis of Non-Circular Injection-Driven Channel Flows," Maxime Bouyges, Francois Chedevergne, and Gregoire Casalis, ONERA.

AIAA Spacecraft Structures Best Paper
AIAA 2016-2165, "Starshade Mechanical Architecture & Technology Effort," David R. Webb, Brian Hirsch, Vinh Bach, Jonathan Sauder, Samuel Case Bradford, and Mark Thomson, Jet Propulsion Laboratory.

AIAA Walter Lempert Student Paper Award in Diagnostics for Fluid Mechanics, Plasma Physics and Energy Transfer
AIAA 2017-0152, "Simultaneous High Speed (5 kHz) Fuel-PLIF, OH-PLIF and Stereo PIV Imaging of Pressurized Swirl-Stabilized Flames using Liquid Fuels," Iianko Chterev, Georgia Institute of Technology.

ASEE Propulsion Education Best Paper
AIAA 2016-4723, "K-12 Minority STEM Education Program: MAA Southwest," Haritha Keerthi, Patricia Uptergrove, Michael L. Everett, Norman D. Love, and Ahsan R. Choudhuri, University of Texas, El Paso.

ASME/Boeing Best Paper Award
AIAA 2016-0936, "A Coupled Electromechanical Peridynamics Framework For Modeling Carbon Nanotube Reinforced Polymer Composites," Naveen Prakash and Gary Seidel, Virginia Polytechnic Institute and State University.

ASME Propulsion Best Paper
AIAA 2016-4813, "Experimental Investigation of a Baffled-Tube Ram Accelerator," C. Knowlen, J.F. Glusman, R. Grist, and A.P. Bruckner, University of Washington; and A.J. Higgins, McGill University.

STUDENT PAPER COMPETITION WINNERS

AIAA Atmospheric and Space Environment Student Paper Competition
AIAA 2017-4375, "3D Computational Icing Method for Aircraft Conceptual Design," Gustavo Eidji and Camarinha Fujiwara, University of Washington.

AIAA Atmospheric Flight Mechanics Student Paper Competition
AIAA 2017-1186, "Cyclic Blade Pitch Control for Small UAV Without a Swashplate," James Paulos and Mark Yim, University of Pennsylvania-Philadelphia.

AIAA Multidisciplinary Analysis Optimization Student Paper Competition
AIAA 2017-3330, "Aerodynamic Design Exploration through Surrogate-Assisted Illumination," Adam Gaier, University of Lorraine/Bonn-Rhein-Sieg University of Applied Sciences.

American Society for Composites Best Student Paper Award
AIAA 2016-1499, "Modeling the Bistability of Laminated Composite Toroidal Slit Tubes," Geoffrey Knott and Andrew Viquerat, University of Surrey.

Harry H. and Lois G. Hilton Student Paper Award in Structures
AIAA 2016-0724, "3D Delamination Profile Reconstruction for Composite Laminates using Inverse Heat Conduction," Tishun Peng, Arizona State University; and Yongming Liu, Arizona State University.

Jefferson Goblet Best Student Paper Award
AIAA 2016-1241, "Thermally-Driven Morphing with High Temperature Composites," Eric Eckstein, University of Bristol; Michael Halbig, NASA Glenn Research Center; and Paul Weaver, University of Bristol.

Lockheed Martin Student Paper Award in Structures
AIAA 2016-0490, "Thermal Response of a Spatially Graded Metal-Ceramic Structural Panel to Non-Uniform Heating in Hypersonic Flow," Phillip Deierling, University of Iowa; and Olesya Zhupanska, University of Arizona; and Crystal Pasiliao, Air Force Research Laboratory.

Southwest Research Institute Student Paper Award in Non-Deterministic Approaches
AIAA 2016-0952, "Robust Test Resource Allocation using Global Sensitivity Analysis," Chenzhao Li and Sankaran Mahadeven, Vanderbilt University.

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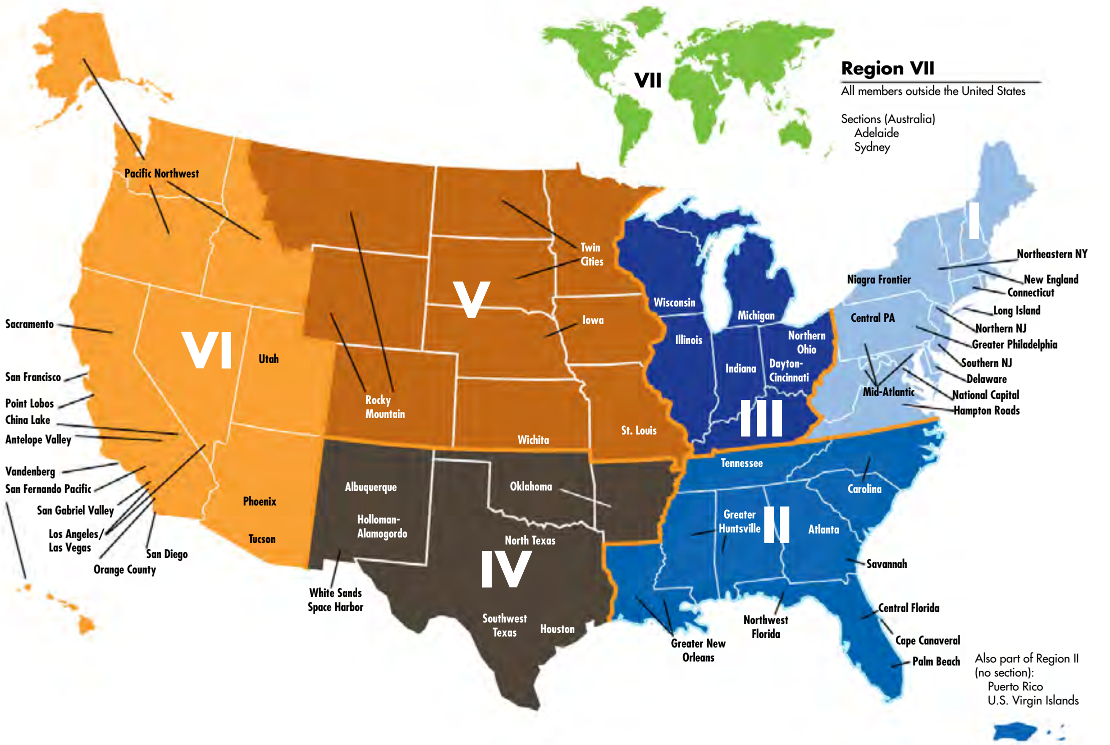

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Elfego Pinon *STEM K-12 Officer*
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John Tam *Education Officer*
Randy Truman *University Liaison Officer*
Benjamin Urioste *Newsletter Editor*
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Jessica Piness *Vice Chair, Education Officer*
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Spencer Shupe *Secretary*
Samuel Silver *Website Editor*
Mark Snaufer *Treasurer, Honors & Awards Chair*
Charles Vono *Chairman Emeritus*

Vandenberg
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Mark Hawes *Programs Officer*
Nathan Luallen *Technical Officer*
Thomas Stevens *STEM K-12 Officer*

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Saman Aghdam *Treasurer*
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Warrick Miller *Vice Chair*
Matthew Tetlow *Chair Emeritus, Technical Officer*
Ian Tuohy *Council Member*

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David Jarrett *Council Member*
Divya Jindal *Young Professional Officer*
Benjamin Kaebe *Council Member*
Christopher Leow *University Liaison Officer*
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Timo Moisiadis *Website Editor*
Vasili Moisiadis *Social Media*
Benjamin Morrell *Council Member*
Andrew Neely *STEM K-12 Officer*
Ubair Rehmanjan *Vice Chair - Sydney*
Evan Smith *STEM K-12 Officer*
Michael Spencer *Honors & Awards Chair*
Muddasir Tahir *Council Member*
Matthew Vella *Council Member*
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PROTOCOL

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Faculty Positions in Robotics, Dynamics and Control

The College of Engineering and Applied Science at the University of Colorado Boulder invites applications for three tenure-track faculty positions beginning fall 2018. We are interested in candidates with demonstrated strong theoretical or applied research experience in robotics, dynamics and control. We are especially interested in the following areas: control and dynamical systems, autonomous systems, field robotics, advanced manufacturing, human-robot systems, cyber-physical systems, security and verification, multifunctional/robotic materials, and precision medicine. Candidates must clearly indicate their areas of relevant research expertise in their cover letters. Positions are available at all career levels. By January 1, 2018, interested persons should apply through the web site **https://www.jobsatcu.com/** (Requisition ID: 11154) and submit electronic files (pdf format) containing a cover letter, curriculum vita, two-page statements of research and teaching interests, respectively, and the names, addresses, and telephone numbers of at least three references.

The University of Colorado is an Equal Opportunity Employer committed to building a diverse workforce.

FACULTY POSITIONS
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AFB, DAYTON OH

The Department of Aeronautics and Astronautics seeks applicants for two tenure-track Aerospace Engineering faculty position (preferably at the assistant or associate professor level) and one non-tenure-track Aerospace Engineering faculty position. The first tenure track position is desired in the area of Aeronautical Engineering, namely Hypersonics, Air Breathing Propulsion or Aerodynamics. The second tenure-track position is sought in the area of Astronautical Engineering, namely Spacecraft Design and Controls. While expertise in these disciplines will be given preference, other expertise will be considered. The non-tenure-track position is targeting Hypersonics and/or Aerothermodynamics. In addition to an earned Ph.D. in Aeronautical Engineering, Astronautical Engineering, Mechanical Engineering or a related field, candidates for all three positions should have demonstrated or show a potential ability in teaching at the graduate level and in conducting independent research for the Air Force and other government agencies. Good communication skills, both oral and written, are essential. Applicants must be U.S. citizens. Applicants must currently possess or be able to obtain/maintain a TOP SECRET clearance if applying for a Hypersonics positon or a SECRET clearance if applying for any other position. If selected, applicants must produce proof of citizenship at time of appointment. Link to full posting can be found at **https://www.usajobs.gov**

The Department offers both M.S. and Ph.D. degrees in Aeronautical Engineering, Astronautical Engineering, Space Systems and Materials Science. The Department has several state-of-the-art computer and experimental laboratories. Interested candidates must apply for the position through USAJOBS (see link above). Questions regarding the position may be addressed to:

Dr. Brad S. Liebst, Professor and Head,
Department of Aeronautics and Astronautics, Air Force Institute of Technology
AFIT/ENY
2950 Hobson Way, Wright-Patterson AFB, OH 45433-7765
Phone: (937) 255-3069, e-mail: Bradley.Liebst@afit.edu

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AUBURN UNIVERSITY

SAMUEL GINN
COLLEGE OF ENGINEERING

Aerospace Engineering

Multiple Tenure Track Faculty Positions

The Department of Aerospace Engineering at Auburn University invites applications for multiple tenure-track and tenured faculty positions at the Assistant, Associate and Full Professor level. Areas of immediate interest include flight dynamics & control; orbital mechanics and space sciences; remote sensing; guidance, navigation and control; aerospace design and manufacturing; aerospace systems; unmanned aerial systems; and experimental fluid dynamics. Candidates with strong backgrounds in other areas relevant to aerospace engineering are also welcome to apply and will be fully considered as part of the current search.

Senior level candidates with a strong interest in providing mentorship and leadership to a young, enthusiastic and rapidly growing department are particularly encouraged to apply. Senior level candidates are also eligible for a Walt and Virginia Woltosz Professorship. All candidates will be expected to fully contribute to the department's mission through the development of a strong, nationally recognized, funded research program, teaching at both the undergraduate and graduate level, and professional service. Successful candidates will have a demonstrated track record of scholarship, a creative vision for research, an active interest in engineering education and strong communication skills. Candidates must have an earned doctorate in aerospace engineering, mechanical engineering or a closely related field.

Candidates can login and submit a cover letter, CV, research vision, teaching philosophy, and three references at: https://aufacultypositions.peopleadmin.com/postings/1871 Cover letters may be addressed to: Dr. Brian Thurow, Search Committee Chair, 211 Davis Hall, Auburn University, AL 36849. To ensure full consideration, candidates are encouraged to apply before December 1, 2017 although applications will be accepted until the positions are filled. The successful candidate must meet eligibility requirements to work in the U.S. at the time the appointment begins and continue working legally for the proposed term of employment. Additional information about the department may be found at: http://www.eng.auburn.edu/aero/

Auburn University is one of the nation's premier public land-grant institutions. In 2018, it was ranked 46th among public universities by U.S. News and World Report. Auburn maintains high levels of research activity and high standards for teaching excellence, offering Bachelor's, Master's, Educational Specialist, and Doctor's degrees in agriculture and engineering, the professions, and the arts and sciences. Its 2017 enrollment of 29,776 students includes 23,964 undergraduates and 5,812 graduate and professional students. Organized into twelve academic colleges and schools, Auburn's 1,450 faculty members offer more than 200 educational programs. The University is nationally recognized for its commitment to academic excellence, its positive work environment, its student engagement, and its beautiful campus.

Auburn residents enjoy a thriving community, recognized as one of the "best small towns in America," with moderate climate and easy access to major cities or to beach and mountain recreational facilities. Situated along the rapidly developing I-85 corridor between Atlanta, Georgia, and Montgomery, Alabama, the combined Auburn-Opelika-Columbus statistical area has a population of over 500,000, with excellent public school systems and regional medical centers.

In support of our strategic plan, Auburn University will maintain its strong commitment to diversity with standards to help ensure faculty, staff, and student diversity through recruitment and retention efforts.

Auburn University is an EEO/Vet/Disability Employer

USC University of Southern California

The Department of Aerospace and Mechanical Engineering at USC is seeking applications for tenure-track or tenured faculty candidates. We seek outstanding candidates for a position at any rank. The Viterbi School of Engineering at USC is committed to increasing the diversity of its faculty and welcomes applications from women, underrepresented groups, veterans, and individuals with disabilities.

We invite applications from candidates knowledgeable in all fields of aerospace and mechanical engineering, with particular interest in advanced manufacturing and robotics, aerospace structures, energy engineering/propulsion, and physics-based computational engineering. Applications are also encouraged from more senior applicants whose accomplishments may be considered transformative. Outstanding senior applicants who have demonstrated academic excellence and leadership, and whose past activities document a commitment to issues involving the advancement of women in science and engineering may also be considered for the Lloyd Armstrong, Jr. Endowed Chair, which is supported by the Women in Science and Engineering (WiSE) Program endowment.

Applicants must have earned a Ph.D. or the equivalent in a relevant field by the beginning of the appointment and have a strong research and publication record. Applications must include a letter clearly indicating area(s) of specialization, a detailed curriculum vitae, a concise statement of current and future research directions, a teaching statement, and contact information for at least four professional references. Applicants are encouraged to include a succinct statement on fostering an environment of diversity and inclusion. This material should be submitted electronically at **http://ame.usc.edu/facultypositions/.** Applications should be submitted by December 15, 2017; any received after this date may not be considered.

USC Viterbi
School of Engineering

USC is an equal opportunity, affirmative action employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, protected veteran status, disability, or any other characteristic protected by law or USC policy. USC will consider for employment all qualified applicants with criminal histories in a manner consistent with the requirements of the Los Angeles Fair Chance Initiative for Hiring ordinance.

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University of Colorado Boulder

Engineering & Applied Science
UNIVERSITY OF COLORADO BOULDER

Faculty Positions in Thermal and Fluid Sciences

The College of Engineering and Applied Science at the University of Colorado Boulder invites applications for two tenure-line faculty positions beginning fall 2018. We are particularly interested in candidates with demonstrated strong research experience in thermal and fluid sciences. Examples include: high temperature materials, thermal management and control for space systems, energy management, solar thermal applications, water desalination, multi-phase flow, high speed aerodynamics, biological flow processes, microfluidics, and combustion and propulsion. One position is at the assistant professor level, and the other position is at the associate or full professor level. By January 15, 2018, interested persons should apply through the web site **http://www.cu.edu/cu-careers** (Requisition ID: 11156) and submit electronic files (pdf format) containing a cover letter, curriculum vita, two-page statements of research and teaching interests, respectively, and the names, addresses, and telephone numbers of at least three references.

The University of Colorado is an Equal Opportunity Employer committed to building a diverse workforce.

DEPARTMENT OF AEROSPACE ENGINEERING - Open Rank Faculty Search

College of Engineering

University of Illinois at Urbana-Champaign

The Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign seeks highly qualified candidates for multiple faculty positions in all areas of aerospace engineering, with emphasis on the areas of aerospace robotics/unmanned aerial systems, experimental hypersonics, and applied aerodynamics/aerospace vehicle design. Preference will be given to qualified candidates working in emerging areas of aerospace engineering whose scholarly activities have high impact. Please visit **http://jobs.illinois.edu** to view the complete position announcement and application instructions. Full consideration will be given to applications received by **November 15, 2017**. Applications received after that date may be considered until the positions are filled.

The University of Illinois conducts criminal background checks on all job candidates upon acceptance of a contingent offer.

The University of Illinois is an Equal Opportunity, Affirmative Action employer. Minorities, women, veterans and individuals with disabilities are encouraged to apply. For more information, visit http://go.illinois.edu/EEO. To learn more about the University's commitment to diversity, please visit http://www.inclusiveillinois.illinois.edu.

AEROSPACE ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Tenure-Track Faculty Position

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT), CAMBRIDGE, MA

MIT AEROASTRO

The MIT Department of Aeronautics and Astronautics invites applications for tenure-track faculty positions with a start date of July 1, 2018 or on a mutually agreeable date thereafter. The department is conducting a search for exceptional candidates with a strong background in any discipline related to Aerospace Engineering, broadly defined. Areas of interest include, but are not limited to:

- advanced materials, manufacturing, mechanics, and structures;
- propulsion, combustion, and environment;
- fluid mechanics and aerodynamics;
- aircraft design;
- autonomous systems;
- interaction of humans and machines;
- air transportation;
- small satellites; and
- space systems and exploration

We are seeking highly qualified candidates with a commitment to research and education. Faculty duties include teaching at the graduate and undergraduate levels, advising students, leading a research program, and service to the institute and the profession.

Candidates should hold a doctoral degree in a relevant field by the beginning of employment. The search is for a candidate to be hired at the assistant professor level; however, under special circumstances, a senior faculty appointment is possible.

Applications must include a cover letter, curriculum vitae, 2-3 page statement of research and teaching interests and goals, and names and contact information of at least three individuals who will provide letters of recommendation. Applicants with backgrounds outside aerospace should describe how a substantial part of their work will apply to aerospace problems. Applications must be submitted as a pdf at

https://school-of-engineering-faculty-search.mit.edu/aeroastro/register.tcl.

Letters of recommendation must be submitted directly by the recommenders at

https://school-of-engineering-faculty-search.mit.edu/letters.

To ensure full consideration, complete applications should be received by December 1, 2017. Applications will be considered complete only when both the applicant materials and at least three letters of recommendations are received.

MIT is building a diverse faculty and strongly encourages applications from female and minority candidates.

For more information on the MIT Department of Aeronautics and Astronautics, please visit **http://aeroastro.mit.edu/**. Applicants may find reading our Strategic Plan (**http://aeroastro.mit.edu/file/strategic-plan.pdf**) helpful in preparing their applications. Questions can be directed to faculty search chair Prof. Steven Barrett (**sbarrett@mit.edu**).

MIT is an Equal Opportunity/Affirmative Action employer.

1917

Nov. 12 Gen. Benjamin Foulois, who learned to fly from the Wright brothers, arrives in France to assume command over all of the U.S. Army Air Service in France. David Baker, **Flight and Flying: A Chronology**, p. 103.

Nov. 21 A heavily modified V-type L-59 Zeppelin airship departs Jamboli, Bulgaria, on a flight to bring supplies and ammunition to beleaguered German forces in East Africa. Although the flight is recalled after the British defeat the Germans there, the L-59 flies for 95 hours and spans 6,800 kilometers without stopping. David Baker, **Flight and Flying: A Chronology**, p. 104.

Nov. 30 The Vickers Vimy long-range heavy bomber takes its first flight when it takes off from the factory at Joyce Green, England. The Royal Air Force flies it from October 1918 until 1924. After World War I, the Vimy sets numerous long-distance records and in 1919 is the first aircraft to fly nonstop across the Atlantic, with famed British aviators John Alcock and Arthur Brown. C.F. Andrews, **Vickers Aircraft Since 1908**, pp. 86-104.

1942

Nov. 2 The Navy establishes the Patuxent River Naval Air Station in Maryland as a testing site for aircraft and equipment. **United States Naval Aviation 1910-1980**, p. 119.

Nov. 8 Operation Torch, the Allied invasion of North Africa, begins when American Douglas C-47 transports attempt to land troops at La Senia, near Oran, Algeria. The planes are flown 2,400 kilometers from England in the longest airborne invasion in history. British Supermarine Spitfires participate in the operation. **The Aeroplane**, Nov. 20, 1942, p. 590, and Dec. 4, 1942, p. 640.

Nov. 8 The National Advisory Committee for Aeronautics' Langley Memorial Aeronautical Laboratory at Langley, Virginia, announces that it will hire women "for vital war work" and they will fill jobs formerly held only by men. M.D. Keller, **Fifty Years of Flight Research: A Chronology of the Langley Research Center, 1917-1966**, p. 53.

Nov. 13 Famed World War I ace Capt. Eddie Rickenbacker, Col. Hans Adamson, and Pvt. John Bartek are rescued in a choppy South Pacific sea 960 kilometers north of Samoa by a Vought-Sikorsky OS2U Kingfisher scout-observation seaplane equipped with float gear. Rickenbacker and his companions have been afloat on a rubber raft for 21 days, since they ditched their bomber when it ran out of fuel. **The Aeroplane**, Nov. 20, 1942, p. 590; **Aero Digest**, January 1943, p. 93.

Nov. 15 The Heinkel He 219 night fighter makes its first flight. The twin-engine plane, which enters combat in June 1943, is the German Air Force's first operational aircraft featuring a retractable tricycle landing gear and is the first World War II aircraft to have crew ejection seats. J.R. Smith and Antony Kay, **German Aircraft of the Second World War**, pp. 298-304.

Nov. 16 The Navy commissions its first night fighter squadron, VMF(N)-531, at Marine Corps Air Station Cherry Point in New Bern, North Carolina. The unit is equipped with twin-engine Lockheed PV-1 aircraft fitted with British Mark IV-type radar. **United States Naval Aviation 1910-1980**, p. 120.

Nov. 23 The VS-173, a full-scale model of an experimental fighter aircraft with an almost circular wing, makes its first flight at the Vought-Sikorsky plant in Stratford, Connecticut. A military version of this aircraft, the XF5U-1, is later built but never flown. **United States Naval Aviation 1910-1980**, p. 120.

Nov. 27 An entire American field hospital is flown into Papua, New Guinea, by 10 large transport planes. The hospital is in working order one day after its arrival. **The Aeroplane**, Dec. 4, 1942, p. 646.

1967

Nov. 1 An Aerobee 150 sounding rocket, carrying a Princeton University scientific payload, ascends to 176 kilometers to determine the UV spectrum of extremely hot atmospheric and interstellar matter in the direction of 05 star Tau Puppis. Excellent film exposures are obtained from the spectrograph. This is one of the few sounding rocket missions to obtain data from deep space. **NASA, Aeronautics and Astronautics, 1967, p. 326**.

Nov. 3 The North American X-15 No. 3 rocket research aircraft crashes into the desert near Johannesburg, California, after it spins out of control in an unpowered descent of about 266,000 feet. The pilot, Air Force Maj. Michael Adams, is killed. This is the first fatality of the X-15 program and the first time one of the three aircraft is damaged beyond repair. **Aviation Week**, Nov. 20, 1967, p. 34.

Nov. 4 Apollo 4 (AS-501) is launched in the first all-up test of the Saturn 5 launch vehicle that also tests the command module heat shield. This is the first time the three stages have flown together and the first use of Complex 39 at Cape Canaveral, Florida. The spacecraft is placed in an Earth parking orbit and after two orbits the third stage is reignited. After 10 minutes the command module and the third stage are separated and land in the Pacific Ocean, near Hawaii. The aircraft carrier USS Bennington recovers the command module after it drops to the ocean attached to a parachute. All this mission's objectives are met. Ivan Ertel, et al., **The Apollo Spacecraft — A Chronology, Vol. 4**, pp. 172-173; **Flight International**, Nov. 16, 1967, p. 817.

Nov. 5 Carl Squier, America's 13th federally licensed pilot and one of its earliest air daredevils, dies in Burbank, California. Born in 1893, Squier became a combat pilot in World War I and served in France. Lockheed Aircraft Co. was on the verge of bankruptcy when he joined it in 1929, just after the stock market crash. Squier provided the organizational genius that kept the company going and made a large impact on the modern American aviation industry. He was Lockheed's greatest salesman and sold aircraft to Amelia Earhart, Wiley Post, Charles Lindbergh and Howard Hughes. **New York Times**, Nov. 7, 1967, p. 41.

Nov. 7 The Surveyor 6 lunar spacecraft is launched by an Atlas-Centaur and becomes the fourth of the Surveyor series to achieve a soft landing on the moon, touching down in the Sinus Medii region and transmitting almost 30,000 images of the lunar surface. **NASA press release 67-287**.

Nov. 10 The ESSA 6 meteorological satellite of the U.S. Environmental Science Services Administration, or ESSA, is launched; its primary objective is to contribute, with other ESSA satellites, in providing global cloud coverage on a daily basis. **ESSA press release 67-82**.

Nov. 13 The Soviet Union's Mikoyan E-266 twin-tailed fighter aircraft, known in the West by its NATO code name of Foxbat, averages 2,903 kilometers an hour over a closed-circuit 1,000-km course that the Soviets claim is a world speed record. **Aviation Week**, Nov. 13, 1967, p. 35.

Nov. 15 France's Mirage 3G variable-sweep fighter prototype undergoes its final high-speed taxi tests at the French Air Force test center at Istres, near Marseilles. **Aviation Week**, Nov. 20, 1967, p. 34.

Nov. 20 Rohini 75, the first Indian-developed rocket, is fired from India's Thumba Equatorial Launching Station near Trivandrum, Travancore, and is designed to carry out meteorological experiments. **Flight International**, Nov. 30, 1967, p. 294.

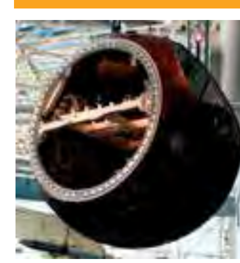
Nov. 28 West Germany's Dornier Do. 31 V/STOL jet transport aircraft makes its first transition from horizontal to vertical to horizontal flight at the Oberpfaffenhofen Airport near Munich. **Aviation Week**, Dec. 4, 1967, p. 31.

Nov. 29 Australia's first satellite, Wretsat, for Weapons Research Establishment Satellite, is launched by a modified U.S. Redstone rocket with two upper stages known as the Sparta, from the Woomera Rocket Range in south Australia, making this country the seventh nation to place a satellite into space. The 45-kilogram scientific satellite is placed into a polar orbit to measure X-ray and ultraviolet radiation and relays data on interaction of solar radiation. **Aviation Week**, Dec. 11, 1967, p. 31.

1992

Nov. 1 Space shuttle Columbia returns after a 10-day flight. During the mission, the crew tested a robotic eye and launched a laser-reflecting satellite. **NASA, Astronautics and Aeronautics**, 1991-1995, p. 269.

Nov. 21 On behalf of the Pentagon, NASA launches the Miniature Seeker Technology Integration-1 satellite on a Scout booster. The satellite is part of plans to detect short- and medium-range missile attacks. **NASA, Astronautics and Aeronautics**, 1991-1995, p. 275.



Nov. 22 The 500-kilogram (1,102-pound) recoverable Resurs 500 (Resource 500) spacecraft is launched from Plesetsk, Russia. It is the country's first private launch, and in a gesture to encourage trade with the U.S., commemorates the 500th anniversary of Columbus' arrival in America. **Washington Post**, Nov. 23, 1992.

MIKE LEWIS, 38

Chief technology officer and chief engineer at NanoRacks

As a boy in New Mexico, a chance encounter at school with geologist and former Apollo astronaut Harrison Schmitt gave Mike Lewis a lifelong interest in space research. It was an interest that would take years of patience to cultivate into a stable, full-time job. In 2012, while working in Houston as a structural engineer in the oil and gas industry, Lewis began working on the side for NanoRacks, the Houston company that arranges experiments on rockets and the International Space Station, an is designing a commecial space habitat. Today, as the top technologist at NanoRacks, Lewis is among those at the forefront of space commercialization.

How did you become an aerospace engineer?

I did my undergraduate in Fort Collins at Colorado State and my master's at the University of Colorado, Boulder, in bioastronautics, basically people and plants in space. That ended up being conveniently relevant to what I do day-to-day now: interacting with astronauts, interacting with the space station as a system, connecting with its power and air and cooling. When I graduated, there was some confusion in the direction of the space program, so I jumped into a structural engineering job, where I was climbing radio towers. I stayed in touch with aerospace by teaching space systems engineering at Webster University in Denver. Next, I worked for Tethers Unlimited near Seattle, developing and testing aerospace mechanisms, sensor and systems. Then, shortly after my wife and I moved to Houston (she works at NASA), I met the founders of NanoRacks. I went to work for an oil field services company as a structural engineer for a bit while moonlighting at NanoRacks. NanoRacks grew organically. Like studio musicians, we would pull in people when we needed them. I did a lot of the engineering on the early projects, the research facilities we put on the space station. I would design late at night at my breakfast table. As NanoRacks gained momentum, I was able to jump in full time.

Imagine the world in 2050. What do you think will be happening in space?

My company is working on the next steps for the commercialization of space stations. In 2050, we are going to see space stations around the moon and, hopefully, around Mars. We'll be a civilization that exists in more than one place. We will be utilizing the resources of other planetary bodies and moving beyond Earth. We will see a lot more cooperation between robotic facilities and manned facilities. Robots are well-suited for the harshness of the radiation environment and you don't have to keep them alive. Robots will be used for fueling, mining and resource utilization. Inevitably, you need mankind up there for inspiration, so people care. People also have the adaptability to be able work through the unforeseen problems. ★

By Debra Werner | werner.debra@gmail.com

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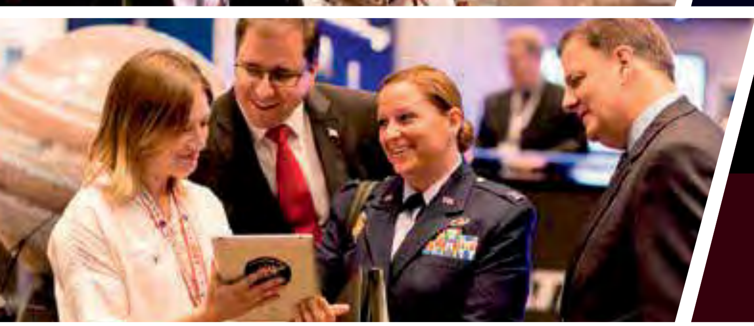

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