

What Apollo can teach Artemis

Predicting overheating

A new role for space-faring governments

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Mach 1 passenger jets could exacerbate aviation's carbon footprint. The search for solutions is underway. **PAGE 22**



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By John M. Logsdon

On the cover: Photo illustration



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OCTOBER 2019, VOL. 57, NO. 9

EDITOR-IN-CHIEF
Ben Iannotta
beni@aiaa.org

ASSOCIATE EDITOR
Karen Small
karens@aiaa.org

STAFF REPORTER
Cat Hofacker
catherineh@aiaa.org

EDITOR, AIAA BULLETIN
Christine Williams
christinew@aiaa.org

EDITOR EMERITUS
Jerry Grey

CONTRIBUTING WRITERS

Keith Button, Adam Hadhazy,
Robert van der Linden, John M. Logsdon,
Debra Werner,
Frank H. Winter

John Langford **AIAA PRESIDENT**
Daniel L. Dumbacher **PUBLISHER**
Rodger S. Williams **DEPUTY PUBLISHER**

ADVERTISING
advertising@aiaa.org

ART DIRECTION AND DESIGN
THOR Design Studio | thor.design

MANUFACTURING AND DISTRIBUTION
Association Vision | associationvision.com

LETTERS AND CORRESPONDENCE
Ben Iannotta, beni@aiaa.org

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Aerospace America (ISSN 0740-722X) is published monthly except in August by the American Institute of Aeronautics and Astronautics, Inc., at 12700 Sunrise Valley Drive, Suite 200 Reston, VA 20191-5807 (703-264-7500). Subscription rate is 50% of dues for AIAA members (and is not deductible therefrom). Nonmember subscription price: U.S., \$200; foreign, \$220. Single copies \$20 each. Postmaster: Send address changes and subscription orders to Aerospace America, American Institute of Aeronautics and Astronautics, at 12700 Sunrise Valley Drive, Reston, VA, 20191-5807, Attn: A.I.A.A. Customer Service. Periodical postage paid at Reston, Virginia, and at additional mailing offices. Copyright 2019 by the American Institute of Aeronautics and Astronautics, Inc., all rights reserved. The name Aerospace America is registered by the AIAA in the U.S. Patent and Trademark Office.



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

John is professor emeritus at George Washington University and has written books on the space policies of U.S. Presidents Kennedy, Nixon and Reagan. He founded GW's Space Policy Institute in 1987 and directed it until 2008. He is editor of "The Penguin Book of Outer Space Exploration."
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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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AeroVironment electrical engineer Michael Seitz

Deep space could jolt how we see ourselves

Registrations for the tours of NOAA's National Center for Weather and Climate Prediction tied to this month's International Astronautical Congress were filled to capacity by mid-September, according to the IAC website.

I guess it should not be surprising that many of those who are interested in the workings of far-off celestial bodies tend to be interested in the atmosphere they breathe every day.

In fact, I will dare to predict that the more Americans, Chinese, Europeans and Indians learn about other worlds, the more they will realize how rare, precious and tenuous our own existence is.

The CO₂ from these four leading polluters ends up in our atmosphere shown above in a photo from the International Space Station. Viewing Earth as part of the cosmos — a beautiful place where life is rare — tends to make us want to do better, doesn't it?

This prediction of a celestially inspired wake-up call is bold, but it's not without historical underpinnings. Within two years of the famous Earthrise photo shot on Christmas Eve during the Apollo 8 orbit of the moon, the U.S. created the Environmental Protection Agency, a step that was followed by the Clean Water Act and a slew of environmental laws.

Apollo may have accomplished what Rachel Carson's 1962 book "Silent Spring" could not do alone.

Flash forward, and it's safe to say that the NASA program to return U.S. boots to the moon was in no way inspired by environmentalism, but I postulate that could be one of the endeavor's unanticipated outcomes.

Perhaps if the Apollo program had not been canceled, it would not have taken so long for 73% of Americans to recognize that global warming is happening and for 62% to agree that it is mostly caused by humans, to give figures from a survey by Yale University.

As significant as the International Space Station program has been in many ways, it will never be as dynamic and attention grabbing as exploring deep space and building a space economy.

Of course, it'll take more than pretty pictures and testimonials to keep humanity in deep space. My sense is that if entrepreneurs don't make space a dynamic place with direct benefits for those on Earth, then the proposed Artemis 2024 landing will turn out to be yet another one-off dabbling beyond low Earth orbit. ★

▲ The Earth's limb from the International Space Station. Blue layers are the middle and upper atmosphere.

NASA



A stylized, handwritten signature in black ink that reads "Ben Iannotta".

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

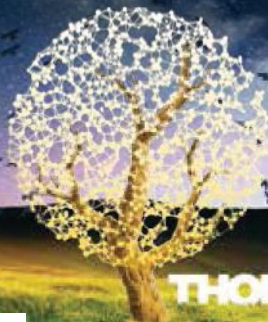
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experience as a writer and editor in the aerospace and technology
industries. Iannotta's work has been published by *Aerospace America*;
Air and Space, *Smithsonian*, *New Scientist*, *Popular Mechanics*, and
Reuters News Service.



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Building the Space Economy — A Marriage of Technology and Business

The world is finally excited about space again. Companies are building lunar landers to return to the moon, we are preparing to watch humans be launched to the International Space Station on commercial vehicles from the United States, and you can soon buy a tourist ticket to low Earth orbit. Add the Artemis program that will launch and land the first woman on the moon and it creates quite a Sci-fi story. Not since the glory days of the Apollo program has the passion for space been greater than it is today. But a key element to retaining this spark of enthusiasm is to create and retain a strong space economy, something that keeps us all coming back.

Some credit for this resurgence in a desire to “Boldly go where no man, or woman, has gone before” belongs to Blue Origin, Space X, Virgin Galactic, and other commercial entities whose business models are built on escaping the Earth’s gravity, both as government partners and on their own. Sure, some of these new endeavors are co-funded by billionaires, and the enthusiasm is part of the marketing plan, but the magic of these programs is that the development is no longer solely limited to government agencies like NASA and DoD; today the space industry is accessible to all. New entrants, new ideas, stable investment-funding sources, and strong business models are what we need for a strong space economy.

Space is a business now, and this means success will be judged on its profitability, even for people like Jeff Bezos, Richard Branson, Elon Musk, or legacy aerospace companies. All of them need to see returns on their investments for the money to keep flowing into the engineering and construction of new rockets, mining probes, landers, and moon bases.

In the near term, we’ll see a continuation of private companies working with the public sector to provide services once dominated by government entities, such as building, launching and deploying satellites, and delivering cargo and crew to the International Space Station. Within a year or two, however, space tourists will pay big money to orbit the Earth in private spacecraft, potentially have science services on the moon and true space-based global Internet. And farther into the future, satellite probes will attempt to mine and return the rich mineral resources on asteroids and possibly other planets.

However, two very large, yet manageable, obstacles stand in the way of a sustainable space economy.

The first and biggest is ensuring there are strong business models and continual demand for products and services in space. We need to have long-term buyers of technologies and services well beyond the development phases of programs, and not solely dependent on government funding. The industry needs recurring consumers. If people don’t want to buy what we are providing, there is no business case. This critical obstacle is overcome by engineers and business people working in tandem to ensure the efforts are coordinated and have an actual business case that closes.

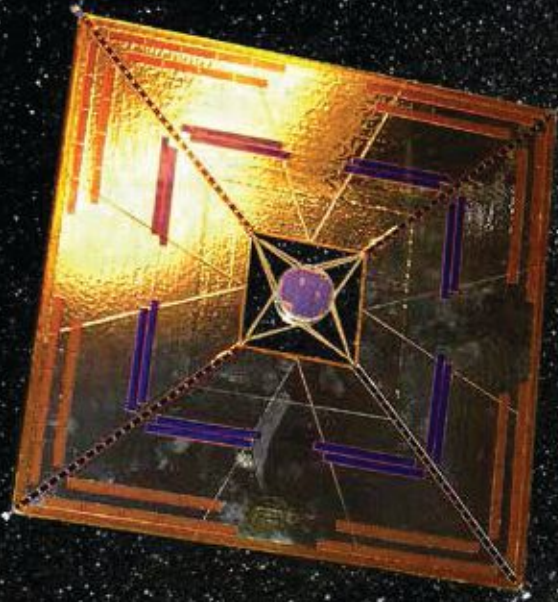
AIAA and its members can play a big role in this future space economy. Starting with a strong level of engagement beyond the technical realm, AIAA can educate its members through engaging events such as ASCEND. Interactive, live events like this bring together critical players and discussions on multiple levels. The stimulation of thought and conversation around a sustainable space economy and market demand, as well as technical challenges, are a core platform to move our industry forward.

The second challenge here in the United States is our workforce. We do not currently have enough people sufficiently trained in engineering and other disciplines critical to success in space. Fortunately, a crucial first step in training a 21st-century space workforce has already begun. STEM programs are being run in elementary, junior high, and high schools to put more young people on trajectories to study math, science, engineering, and computers in college.

We must harness the excitement we now experience about space and instill it in students by initiating internships, ensuring strong mentoring programs, and creating partnerships with academia. And we need to get more involved in shaping the academic curricula at our colleges and universities. Our goal should be to train engineers who understand business and business people who understand engineering. This is the 21st-century space workforce our industry needs to achieve technical and financial sustainability. ★

Heather Bulk

CEO and Co-Founder, SAS
AIAA Senior Member
AIAA Corporate Member



Lightsails versus sailboats

Q. A well-designed sailboat here on Earth can go faster than the wind. Could a spacecraft propelled by a lightsail surpass the speed of light if given enough time to accelerate, notwithstanding Einstein?

Draft a response of no more than 250 words and email it by midnight Eastern time on Oct. 7 to aeropuzzler@aiaa.org.

FROM THE SEPTEMBER ISSUE

PIGSKIN PREVIEW: We asked you what 19th-century British inventor William Hale and your favorite football quarterback have in common.



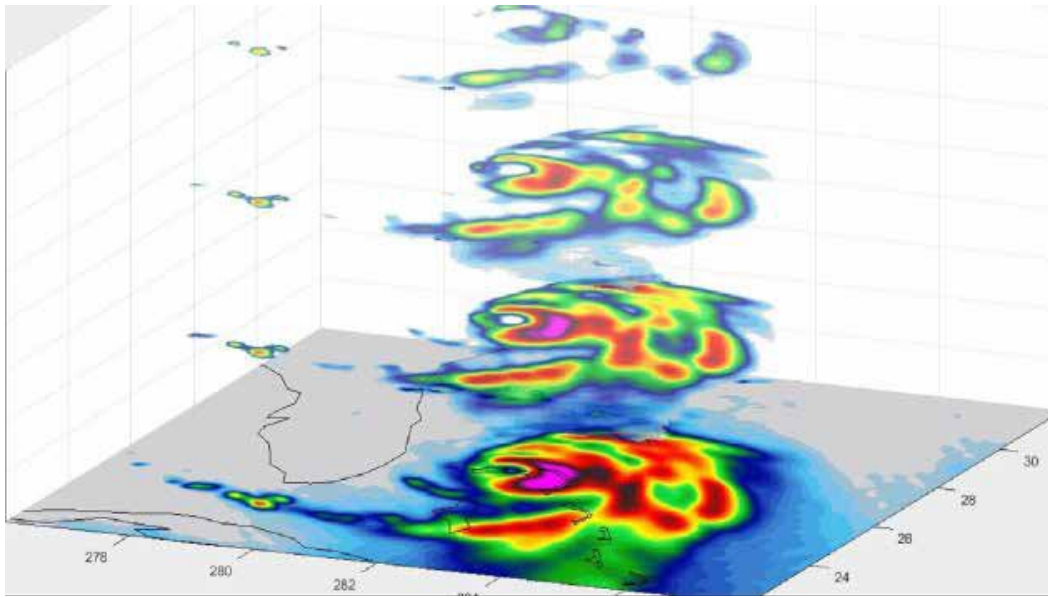
AIAA senior member **Trip Barber**, co-founder of the Team America Rocketry Challenge, reviewed your submissions.

WINNER: William Hale and football quarterbacks share an understanding of aerodynamic spin stabilization. Hale invented the “rotary rocket,” which used exhaust gases to apply torques that spun the rocket on its longitudinal axis. This spin gives the rocket an angular momentum pointed along the longitudinal axis, which makes it harder for disturbance torques to affect the attitude of the rocket. Similarly, quarterbacks apply spin to footballs when they throw them; this is called “throwing a spiral” in football jargon. This spin stabilizes the ball’s orientation as it flies, keeping its axis with the smallest cross-sectional area (and thus, the least aerodynamic drag) oriented along its velocity vector in order to maximize the throwing distance and accuracy.

Nat Guy

AIAA member
Software research and development lead
Astroscale Japan Inc.
Tokyo
nathaniel.guy@gmail.com

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NASA/JPL-Caltech

◀ Hurricane Dorian off the coast of Florida after the storm had devastated the Bahamas, as seen by the six-unit cubesat TEMPEST-D in a still shot taken from an animation. The least-intense areas of rainfall are shown in green, while the most intense are yellow, red and pink.

Seeing inside storms from space

BY CAT HOFACKER | catherineh@aiaa.org

Lots of weather data comes from government satellites as large as pickup trucks, but when it comes to depicting the structure of storms, a cubesat the size of a cereal box is proving bigger isn't necessarily better.

The 11-kilogram cubesat TEMPEST-D, short for Temporal Experiment for Storms and Tropical Systems-Demonstration, gave government scientists and university researchers an interior view of Hurricane Dorian after it destroyed parts of the Bahamas in early September. By measuring the amount of water vapor within the clouds and other factors, TEMPEST-D showed where the rainfall was heaviest within the storm's structure.

"It's pointing the way toward a future that we believe could change weather forecasting," says Steve Reising, the principal investigator for TEMPEST-D and a professor of electrical and computer engineering at Colorado State University.

For now, TEMPEST-D's data is strictly experimental, but the data it has collected from Hurricane Dorian and other storms are publicly available to atmospheric researchers.

TEMPEST-D was designed to track the progression of storms. Inside the six-unit cubesat is a miniaturized microwave radiometer built by NASA's Jet Propulsion Laboratory in California. These sensors measure the wavelengths from thermal electromagnetic radiation that atmospheric gases emit. The radiometer on TEMPEST-D detects those wavelengths at five frequencies, "penetrating into the cloud and looking at different depths" of a storm, Reising says.

"You want to see the storm as it develops vertically and what's going on in the environment around it when the storm forms," Reising says.

From its orbit of 400 kilometers, the cubesat is closer to the

wavelengths emitted from storms like Dorian than the U.S. geostationary satellites positioned about 36,000 km above the equator. "So therefore, if we move a hundred times farther away, we'd have to have a hundred times larger antenna," Reising says.

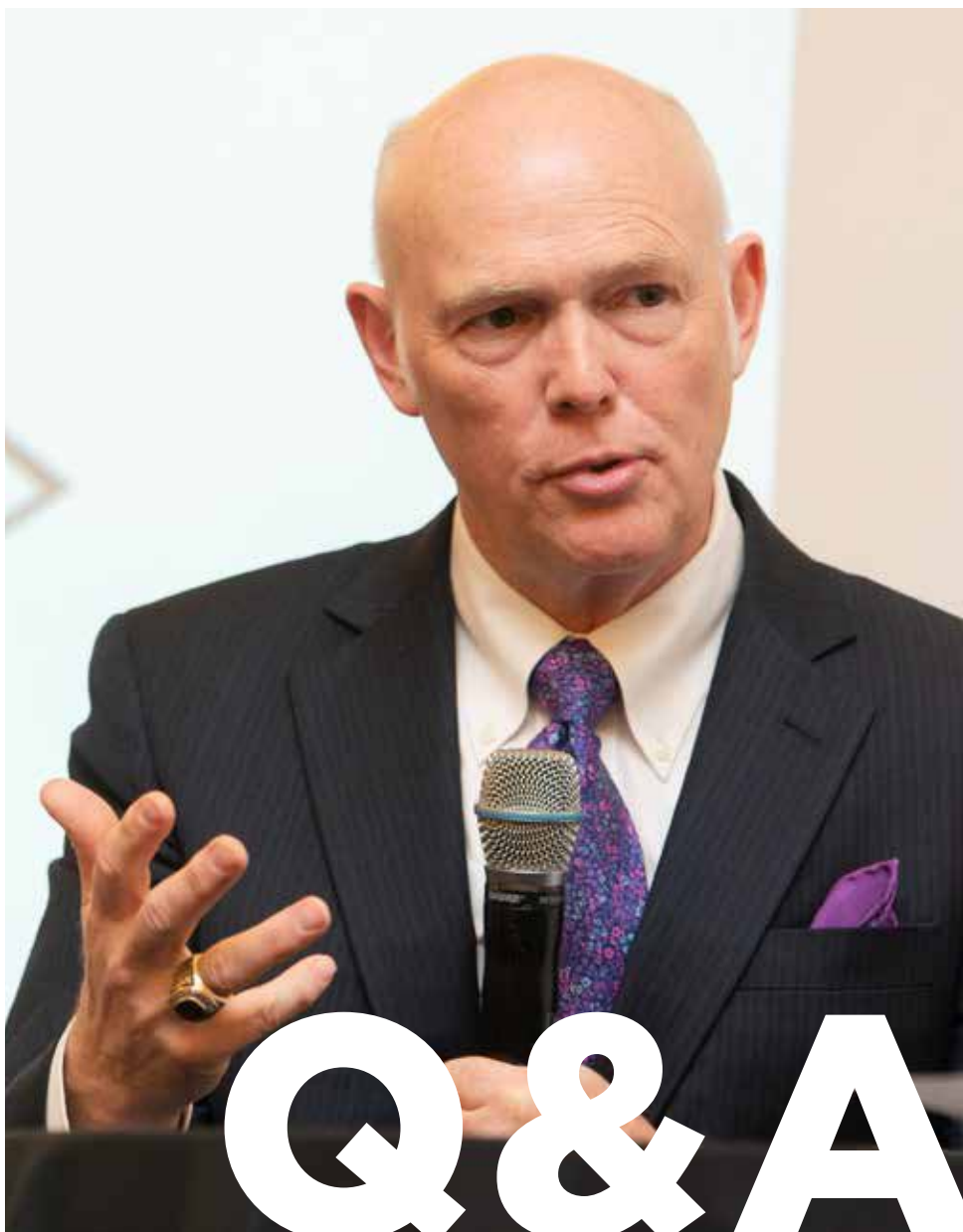
At a fraction of the size and cost of other weather satellites, cubesats could mean "more frequent observations of the same storm at the same cost," Reising says. The TEMPEST-D project, started in August 2015 and funded by an \$8.2 million grant from NASA's Earth Venture Technology Program, took about 2½ years from development to launch.

The spacecraft, which was built and assembled by Blue Canyon Technologies in Colorado, has been in orbit since July 2018. Reising expects the mission to continue until mid-2021, at which point atmospheric drag will pull TEMPEST-D into the atmosphere to burn up from the friction.

But the journey might not end there. The CSU team wants to capitalize on TEMPEST-D's success with a constellation that would supply microwave data to not just scientists but to weather forecasters. Reising envisions the constellation, which would be named TEMPEST, as a line of cubesats trailing one after another in orbit, sampling the changes in clouds and surrounding water vapor every three to four minutes for about 30 minutes.

"For any one storm, most will be seen by one satellite once per day," he says. "The idea of a train of satellites is the first satellite will see the storm, and then boom, three or four minutes later the next satellite comes along to capture that same scene and so on."

In the current concept, TEMPEST would be comprised of six to eight cubesats, but the constellation could be expanded to "as many as make sense," Reising says. ★



TORY BRUNO

POSITIONS: President and CEO of United Launch Alliance in Colorado since August 2014; vice president and general manager of the Strategic and Missile Defense Systems division at Lockheed Martin Space headquartered in Colorado, 2007 to August 2014.

NOTABLE: Joined Lockheed Martin in June 1984 as a summer intern in engineering; in 2014, moved over to ULA as the second CEO in the history of the joint venture formed in 2006 by Boeing and Lockheed Martin. During his years at Lockheed Martin, rose to oversee the update of the U.S. Navy's submarine-launched Trident II D5 fleet ballistic missiles and was in charge of development and initial production of the Terminal High Altitude Area Defense, or THAAD, interceptors that would protect military bases and population centers from attacks by short-, medium- and intermediate-range ballistic missiles.

AGE: 57

RESIDENCE: Denver

EDUCATION: Bachelor of Mechanical Engineering from California Polytechnic State University, San Luis Obispo, 1985

▶ Tory Bruno at this year's AIAA Propulsion and Energy Forum.

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Launching into the future

There are no small jobs in the satellite launching business, but United Launch Alliance CEO Tory Bruno might have one of the biggest. After building a reputation for ULA as a reliable provider with 135 successful launches and counting, Bruno is betting that reputation on development of the successor to the Atlas V rockets called the Vulcan Centaur. Set to debut in 2021, Vulcan's first job will be to end the irony of the U.S. government launching defense and spy satellites on rockets powered in part by Russian-made RD-180 engines. In the long term, Bruno sees the Vulcan as a reusable, flexible launch vehicle for a bustling economy in cislunar space. I spoke with Bruno at the AIAA Propulsion and Energy Forum in Indianapolis.

— Cat Hofacker

IN HIS WORDS

Building the Vulcan

As we have new major systems for Vulcan, we are deliberately feathering them in on Atlas at least a year or more before Vulcan will fly. If I start at the top and work my way down, we developed a brand-new 5.4-meter composite payload fairing for Vulcan, which has a giant, cavernous payload volume. This payload fairing is built in half the time, it costs half the money and it performs better; it's much lighter. That's being fabricated right now by our partner RUAG [Space] inside our Decatur [Alabama] factory, and we will start flying that on Atlas next year. As I come down, the next thing would be the upper stage, Centaur. It is our existing Centaur III but three times the amount of energy, so much bigger propellant tanks. The one thing that will be new is a dual-engine version of that, which we will start flying on our new Starliners [Commercial Crew capsules] starting just in a few months, so that'll have probably four or five flights under its belt before Vulcan flies for the first time. We're reusing all the ordnance. We recently developed a new avionics suite and, since we were doing that, we made it common for Delta, Atlas and Vulcan. So that's been flying for a year already, and because it's the same hardware, 80% of software gets recycled. We're using the same technology for the booster tanks, so rigid structure, 7,000 aluminum, different grid pattern, but basically the same technology. The only thing we won't be able to fly first will be the [Blue Origin] BE-4 engine, and so we'll test the heck out of it on the ground.

First flights

We are confident to go directly to real missions with real customers on our first flights. To be certified for Air Force national security missions, you must fly two times, first for somebody else, and so these are those flights. We just think these are great missions. Peregrine [made by] Astrobotic will be the first big step back to the moon. It's a lunar lander; it's going to carry a couple of dozen payloads to the moon. It just seemed fitting. We have great visions for what will happen on the moon, with cislunar space, so that was part of it. The second flight is with the [Sierra Nevada Corp.] Dream Chaser lifting body vehicle. And I'll tell you, it's the coolest bird. I have been a fan of Dream Chaser from the moment I saw it. We have supported them, we have helped them get to where they are today, and it was a great privilege to receive a block of six missions from them. These were just a really natural fit for us.

Targeted reusability

There's three kind of basic ways to do reusability in a space launch vehicle. You've got glide back like the shuttle, you've got propulsive fly back like that other company's doing, and then you've got component reuse. You know, there are things where you want to go first, be first to market, and then there are other circumstances where it's OK to be second to this. In terms of reuse, I gave them to you in the order of how difficult they are technically and almost the order of how difficult they are to make a business case actually work. Component reuse is a much lower hurdle. You don't have to sacrifice performance of the rocket because you can burn off all your propellant. We already know how to separate and recover bodies — we've done this in the past — so bringing back the [Vulcan] engine is a natural fit. It is two-thirds the cost and value of a first-stage booster. Take the engine away, what do you get? Empty aluminum tanks. Propulsive reuse is pretty tough, and we're going to wait a little bit until we see someone show that as economically sustainable because it has not been shown to be that yet. Then as we learn more about our rocket and how it behaves in the environment it experiences, then we'll move where that technology allows us to go.

One-stop shop for launches

Why one rocket instead of a whole family of rockets? It is the most efficient and cost-effective way to do it. It also greatly simplifies the infrastructure and allows us to focus all of our energy, our innovation, our investments on a single platform to get the most out of it. In advance of Vulcan, we really transformed our whole company. You know, the Atlas rocket launch service now is well over 35, 36% cost reduction from where it was when I joined ULA five years ago. That was largely about reorganizing the company and redesigning how we build the rockets, retiring the venerable Delta that we only maintained for assured access. That's no longer our sole burden, so I don't have to maintain a costly and sort of redundant product line. The second thing is the Vulcan itself. Vulcan is a much more powerful but also much more affordable launch vehicle, and it's really a new class in that it is a single-core heavy. For the heavy missions, it collapses the cost by almost three-quarters in a more flexible vehicle. You will see people that do multiple payloads occasionally on a launch vehicle, dual launch, ride-sharing. We do that too, but one of the challenges in doing that is getting payloads going to the same place at the same time that are a good fit. Vulcan is especially flexible for that, so it will also make it much easier for us to fly two payloads of almost any kind of weight class, three payloads and so on, which further reduces the cost to each customer.

Fast turnaround

We are six times better at flying on time than anyone else in the industry. It's natural for people to not care about the launch until the last few days before it goes, and that's when everybody tunes in. What you don't realize is people generally buy their ride to space about two or three years ahead of time. We set a launch date at that time and we are within, on average, a couple of weeks of that launch date two years later. So losing a few days to make sure it's going to be successful is an obvious thing to do; that's a no-brainer in terms of the decision you make. There are people who have been waiting three years past their flight date that was promised to go to flight. You'll never see that with us. The other thing is with Vulcan, the cycle times are so much shorter. With Vulcan, we can fly 11 days on center off the same pad. Just 11 days apart. That's sort of unprecedented. If you were talking about a scenario that you hear a lot discussed nowadays around operationally responsive space — for example, what if there's an emergency mission, like we need to have a replacement satellite on orbit or we need to get out to ISS or eventually to Gateway — if you are willing to pre-position a relatively inexpensive payload adapter, we can go from this spacecraft being available to its destination orbit in eight days. If you spend a little bit more money and put a payload fairing there as well, five days. I'm feeling pretty good about being able to go from zero to five days in space against anybody in the marketplace.

Flying crew

You have to provide the means by which the capsule can continuously monitor and assess the health of the rocket. In the event that the rocket were to malfunction and the capsule would like to initiate its emergency abort system and fly away, it has to have real-time data coming off the propulsion systems, off of the other critical systems and the rockets. It has the few milliseconds required to accomplish that, so we provide monitoring, we provide cabling, we provide accommodation for the capsule's computer system that does all of that. In addition to that, certain sorts of requirements are of a higher standard in terms of reliability or the environments that might be experienced. So you have to go back and analyze your systems, if you have not already, for those unique requirements to make sure they're satisfied. In some cases, you have to redo a qualification test to demonstrate that the analysis is correct. We did not have to do this on Atlas and do not expect it on Vulcan, but if necessary you might have to make a modification if you found out it wasn't. We'll go through that whole thing on Vulcan should someone ask us to fly people on Vulcan.



Streamlining commercial launches

What we set out to do in this current update to regulations was to streamline the bureaucracy: single forms, simplified forms, not so many different people within the agencies approving things so things can be done more quickly, single licenses for multiple launch sites. That's all streamlining. That's what we wanted to do and largely was accomplished. There's at least one more thing the FAA is still working on, which is coordinating with the Air Force ranges because as it turns out, there's a lot of overlap. When you go to the Air Force, do your work and get their permission to fly, you've done a lot of what you have to do for the FAA. There's an opportunity there for the two organizations to formally coordinate and recognize each other while not letting anything fall through the cracks. That's why you can't just do that instantly. The things that are in

▲ **A Vulcan** structural test booster in the Decatur, Ala., factory awaits testing.
United Launch Alliance

contention are things like a desire, for example, to lower the required reliability for a flight termination system, or perhaps to lower the test levels required to qualify a flight termination system. This is safety. The FAA's primary mission is to protect public safety. The flight termination system is the thing that on a bad day when your rocket isn't working and the thrust vector control is jammed and the front end is on fire and it is flying for the Kennedy Space Center Visitor Complex that their safety officer hits a button and that rocket stops flying. That must work. It has to be reliable. It has to be tested to rigorous conditions, and it has to be able to survive the abnormal environments that occur when your rocket is perhaps breaking apart or on fire. These are fundamental safety requirements, and they cannot be violated. The FAA rules allow for people to demonstrate that they comply with safety by alternate means; that's already there, but to simply say, "We want a lower reliability requirement," I don't think we're ever going to get on the same page with that.

Vulcan's future customers

When they first started talking about proliferated LEO, the architectures were super exciting because they had 3,000 satellites and 4,000 satellites, and they were going to fly in like two years. Then it took them a little bit longer to get funding and to mature, and while they did that, the constellations got better and they all got way smaller because they designed them more effectively. We're still talking about hundreds. They're small spacecraft, and so a hundred satellites is not 100 launches; they will be launched in large groups. Vulcan is really well-suited for taking up the initial constellations. The downside of these is because they're in LEO, which is an hour-and-a-half orbit time, you have no utility with one satellite. You have to get a critical mass of them on orbit before you can start doing a job, earning any money with them. Medium- and heavy-lift vehicles, we'll do the initial population because of that reason. Once they're up, there will be periodic servicing of them. Satellites will die. These constellations, by the way, are inherently robust against an individual bird going out because there's overlap, and because quite frankly in LEO they drift a lot in their orbit with respect to their position in the orbit anyway, so it's easy to re-space them. But if you get a cluster together, now you've got a dead spot, so you're going to have to repopulate. There's a mission there, almost a secondary mission, if you will, for maintenance that I think leaves room for small launchers, and there are a number of small launch companies trying to happen right now. There'll be enough market for two, maybe three. Some of that will still be provided by the medium and heavy lifters, because we have so much capability that when we're taking a primary payload up anyway and it happens to go past where we would drop off a replacement, we would just carry that as a secondary.

"There's at least one more thing the FAA is still working on, which is coordinating with the Air Force ranges because as it turns out, there's a lot of overlap. When you go to the Air Force, do your work and get their permission to fly, you've done a lot of what you have to do for the FAA."

Artificial intelligence on orbit

These proliferated LEO constellations are a great application for AI because enormous quantities of data will be handled through space. AI will enable efficiency of processing some of that data on the orbit before having to transmit it, so you will absolutely see that there. In terms of AI in the design process, well, there is an application for big data. When we design rockets, we don't like to leave out any learning that you could have leveraged, and so you are already seeing a certain amount of, I'll call it, very simple AI involved in the data mining in order to help engineers do the best job when they're designing their parts. More importantly at the moment, though, than that is actually more advanced tools in terms of our ability and coupled analyses that are fully dynamic of all the phenomenon that might happen at a single moment when the rocket is being evaluated. For example, being able to put the propellant fluid column in a single finite element model where it interacts with your structure, creating deformations and strains and stresses to help the design process. Today, that is still more important than big data or other forms of AI. You will see it creep in over time, more on the next generation of rockets, I think, than this one.

AI on the launch pad

What ends up delaying a bird on the pad is weather, it's conditions, sometimes there is an issue that pops up in real time, even though it was tested before, that has to be solved. I would say not the only, but the most interesting application for AI in those circumstances is to be able to answer the question during the countdown before you run out of time. One of the reasons we are as on time as we are is because there's not just the guys in the control center that you see on TV. When we launch a rocket, there's another 150 engineers back in Centennial, Colorado, supporting those people in the control center. Every part that has a responsible engineer, that engineer and their teams are sitting on the console in Denver. They have at their fingertips, on their consoles, all of the data ever collected for their part so that they can decide if it's in family, if it's out of family and how to solve the problem. That's an application that can benefit from AI and one that we're actually working on, but don't tell my competitors. ★



Decoding the boundary layer at hypersonic speeds

The U.S. is reinvigorating its basic research toward hypersonic flight. One product of that initiative is a sounding rocket that's scheduled to take off from Sweden next year. It will gather never-before-collected flight data that could help pave the way for development of weapons or vehicles that would maneuver over long ranges in the atmosphere at more than five times the speed of sound, something that no known weapon today can do. [Keith Button](#) tells the story.

BY KEITH BUTTON | buttonkeith@gmail.com



Next May, if all goes as planned, a sounding rocket will soar to an altitude of nearly 300 kilometers over a test range in Sweden, and as it descends it will accelerate to a hypersonic speed of Mach 7 to 7.5. A nearly meter-long metal wedge on its tip will gather hundreds of aerodynamic measurements for the U.S. Air Force Research Lab.

U.S. engineers hope that this experiment called BOLT, short for Boundary Layer Transition, will tell them when the thin layer of air flowing smoothly over the surface of the wedge turns turbulent, and where on the shape this transition begins.

"If you're actually trying to make something that flies, you should know that, right?" says AFRL's Ivett Leyva, the BOLT project manager and creator.

An unexpected transition to turbulent flow risks overheating a future hypersonic vehicle, so designers need the ability to predict when and where this will happen on a vehicle's shape. BOLT's wedge shape, however, is not meant to represent any particular vehicle. This is a \$6 million basic research project that includes the \$2.4 million flight in Sweden.

BOLT is an example of the basic research that underlies a multibillion-dollar U.S. initiative to catch up to a perceived lead by China in hypersonics and what the U.S. views as Russia's more dubious claim that it has already fielded hypersonic weapons. Hypersonic weapons might be propelled by air-breathing supersonic combustion ramjets, known as scramjets, or by rockets accelerating through space before returning to the atmosphere

in a "boost-glide" design. Verified, maneuverable hypersonic weapons would be formidable: faster than the fastest bullets in the world and seven times faster than most cruise missiles.

The U.S. until now has muddled through in the hypersonic realm without firm data about the boundary layer transition. "If you have uncertainty on how hot your flying object is going to get, you have to think how you're going to survive with that uncertainty," explains Leyva.

When engineers can't accurately predict the transition to turbulent flow, they must design conservatively. This was the case with the space shuttle orbiters. Each was protected during reentry by heat-absorbing tiles designed to withstand greater heat than was probably necessary. The concern is that swirls in the turbulent flow mix the boundary layer air much more than the smooth, laminar flow occurring before the transition. This mixing drags more high-speed flow close to the surface, which creates a lot more friction and up to eight times the heat created by laminar flow.

A different shape

The wedge is 87 centimeters long with a snub nose, swept leading edges and slightly concave surfaces. This shape presents more aerodynamic challenges than the cone and elliptical-cone tested under a previous U.S.-Australian effort called HIFiRE, short for Hypersonic International Flight Research Experimentation.

The location of a boundary layer transition varies with a large number of factors, including the vehicle

▲ Texas A&M University

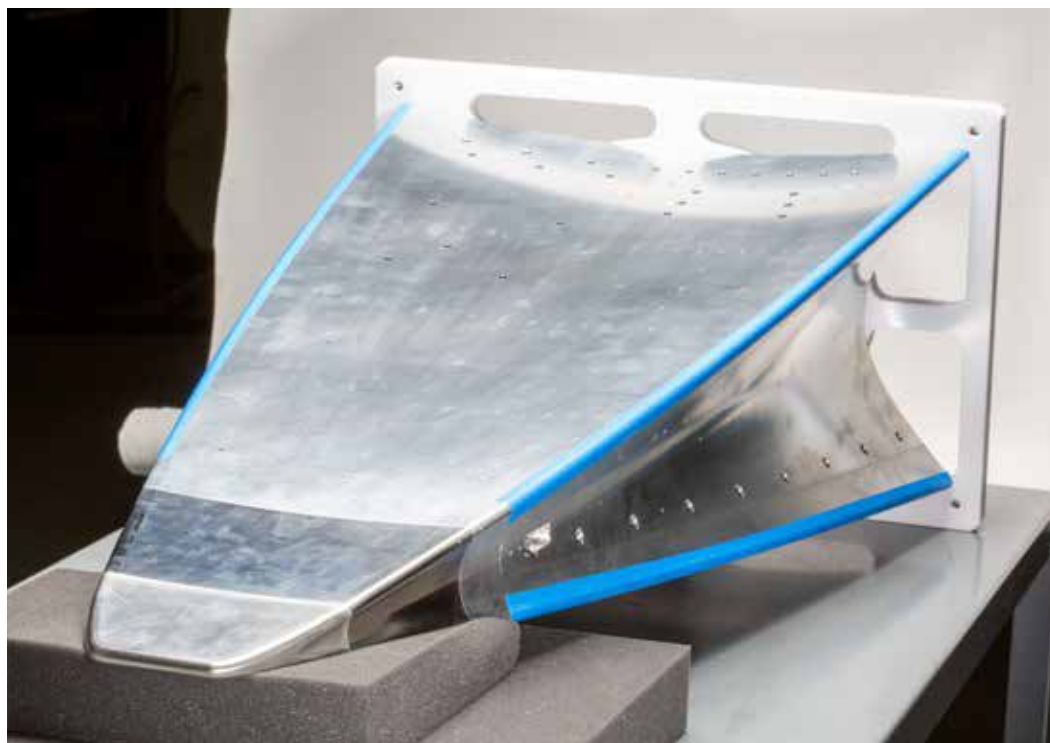
student researchers test the BOLT subscale wind-tunnel model in the university's Mach-6 Quiet Tunnel facility in College Station. Graduate students from across the country have participated in the planning of the hypersonic flight test experiment.

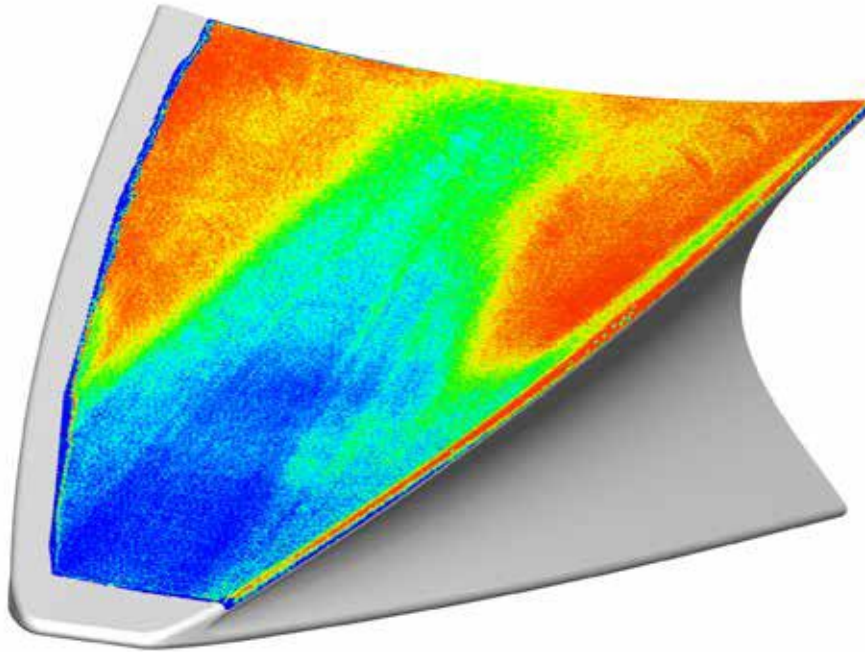
AFRL/Texas A&M University

▶ This metal tip will be

on the top of the rocket assembly next May.

AFRL/Johns Hopkins APL





◀ **A visualization of surface heat** transfer derived from temperature-sensitive paint on a full-scale BOLT model in the CUBRC LENS II shock tunnel in Buffalo, N.Y. Regions of higher heating, seen in orange and red, are due to boundary layer transition.

AFRL/Johns Hopkins APL

shape, altitude, orientation of vehicle, materials of the vehicle, its surface texture, temperature of the surface, Mach number and Reynolds number, which is the ratio of inertial forces to viscous forces in the air flow. Generally, the higher the Reynolds number, the greater the likelihood of turbulent flows. The effect of the Mach number is not as clear-cut, says aerospace engineer Dennis Berridge, the BOLT co-investigator from Johns Hopkins University Applied Physics Laboratory.

Wind tunnel differences

One challenge facing the BOLT team was that no single wind tunnel facility could reproduce every aspect of the flight environment. Some tunnels are “quiet,” meaning their walls exhibit smooth laminar flow, but they can provide only one velocity of hypersonic flow and accommodate only small shapes. Some tunnels that can test larger shapes provide only a few milliseconds of flow.

The team decided it would need to test multiple versions of the wedge, made from metal or plastic in several sizes, in multiple tunnels and “stitch together what would happen in flight,” Berridge says.

Engineers were also concerned about the risk of noise, meaning disturbances caused by the tunnel walls. So they tested some shapes at the quiet tunnels at Purdue University and Texas A&M. Other tests were conducted in Buffalo, New York, at the research company CUBRC (formerly the Calspan-University at Buffalo Research Center) and at NASA’s Langley Research Center in Virginia. These facilities can accommodate larger models at full-flight velocity but with noise from the turbulent flow along the walls, Berridge says.

“There’s not a single wind tunnel that we’ve dreamt of and built that can catch all of these requirements and give us good flow. It just doesn’t exist. So we have to fly.”

— Ivett Leyva, the BOLT project manager and creator

Stitching all these measurements together was helpful but imperfect. That’s why the May flight test will be so important, Leyva says.

“There’s not a single wind tunnel that we’ve dreamt of and built that can catch all of these requirements and give us good flow. It just doesn’t exist. So we have to fly,” she says. “It’s just the natural environment where you want to understand the physics.”

Another challenge for the scientists has been how to measure the boundary layer flows. Two measures signal when laminar flow is transitioning to turbulent flow: heat and pressure variations.

To measure pressure, the engineers drilled 3-millimeter holes in the BOLT wedge shape for small cylinder-shaped pressure sensors, inserted from the inside of the shape to be flush with the surface of the shape, with the sensing surface exposed to the air flowing over the shape.

To measure heat, the engineers pointed infrared cameras at the model to detect where the temperatures started rising, indicating potential transitional flow. They also painted some of the models with temperature-sensitive paint, excited the molecules

in the paint with blue light, then pointed a camera at the model to detect temperatures shown by color variations in the paint.

Flight test

AFRL contracted with the German aerospace agency, DLR, to launch the test shape — made of aluminum, a titanium-zirconium-molybdenum alloy and stainless steel — on the 8.4-meter sounding rocket. As for the status of the preparations, U.S. scientists have built the hardware for the flight experiment and should have the instrumentation built for measuring the test by October. The test will be at the Esrange Space Center in Sweden, chosen by DLR so the rocket can be retrieved on land. The AFRL will provide electronics for the rocket, borrowing from electronics it developed with Australia for the HIFiRE flights.

Engineers will collect 340 measurements of temperature, pressure and heat transfer as the wedge accelerates to a maximum hypersonic velocity of somewhere between Mach 7 and Mach 7.5 after it reenters the atmosphere. At that point, the rocket's tip and wedge will separate and fall to the ground about 60 k down range. Some data will be transmitted during the experiment, and the rest will be collected from a hard drive in the tip after it is recovered.

Preparing for the flight test and potential things that could go wrong puts a lot of pressure on the team, says Brad Wheaton, APL aerospace engineer and BOLT principal investigator. "It's a one-time shot. That's what makes hypersonic testing exciting."

The BOLT experiments are breaking new ground for hypersonics knowledge, and scientists will be studying and interpreting the test results for many years as they build on the BOLT research findings, just like scientists are still studying HIFiRE results

Future plans: BOLT II

Once they launch their wedge-shaped structure to hypersonic speeds and recover it, engineers from the U.S. Air Force Research Lab will move onto their next flight experiment in which they plan to launch an elongated version of the wedge to hypersonic velocities.

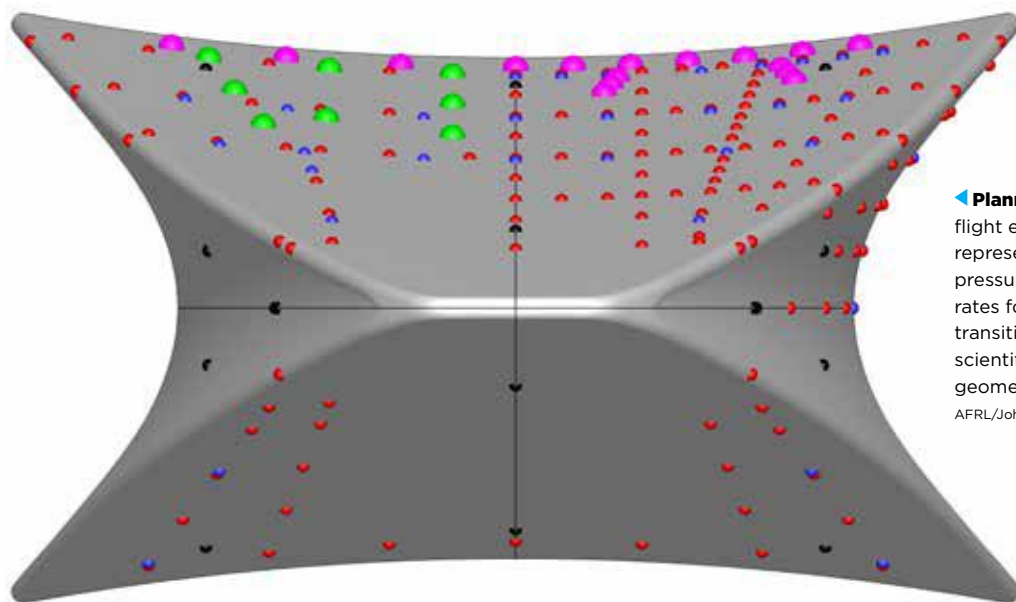
This Boundary Layer Transition II wedge will be launched on a sounding rocket sometime in 2021 from NASA's Wallops Flight Facility in Virginia. The elongated BOLT II wedge is designed to create more hypersonic turbulent flows than the original BOLT wedge that in May 2020 will soar over a test range in Sweden, if all goes as planned.

The BOLT II project was started on May 1, and hypersonic wind tunnel testing is underway at Texas A&M in College Station, Texas.

BOLT II is expected to be similar in scope and cost to the \$6 million BOLT project, with testing at several hypersonic wind tunnels leading up to the flight test, says AFRL's Ivet Leyva, creator and manager of BOLT and BOLT II. Leyva is still assembling the project teams. BOLT II may also incorporate new types of instrumentation to measure factors in addition to the temperature and pressure variations examined by the BOLT team, Leyva says.

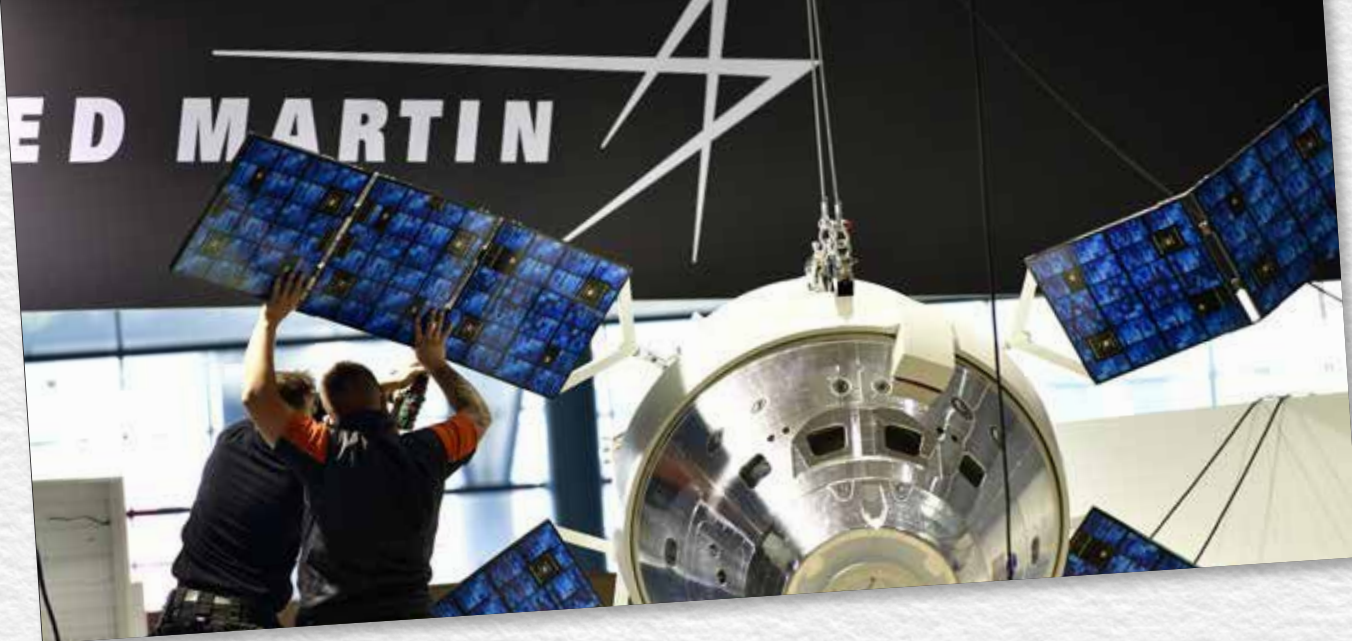
— Keith Button

10 years later, Leyva predicts. "We feel pretty good that we can digest the differences that we have seen so far from this to the other simpler geometries. We kind of understand why they're different," she says. "Now we are going into this way more complex geometry, and we are getting way more complex physics. We are not in the business of doing things just to validate computer models; we are in the business of creating an understanding of physics. We are in the business of creating new science." ★



▶ **Planned sensors on the BOLT** flight experiment. Each colored dot represents a measurement of surface pressure, temperature or heat transfer rates for detecting boundary layer transition. Researchers plan 340 scientific measurements on the BOLT geometry.

AFRL/Johns Hopkins APL



REPORTER'S PICKS

My game plan for IAC

I've always thought there was a certain irony in the place Apollo 11 holds in our history. The moon landing was inspired by the Cold War struggle between two competing nations but ultimately celebrated as perhaps humanity's greatest collective accomplishment. Now, as the U.S. and other nations again set their eyes on the moon, I have to wonder whether this revitalization is motivated by national pride or if we'll see humanity come together at the moon and reach out into deep space together.

I don't know the answer, but the International Astronautical Congress seems like a good place to start digging into these ideas.

This five-day gathering of government and industry space leaders from across the globe was first held in 1950 by the Paris-based International Astronautical Federation. IAC is now held in a different country each year, with a local host organization — in this case AIAA — planning and organizing the gathering.

As of this writing, about 3,000 people from 64 countries have registered to attend the event in downtown Washington, D.C. AIAA expects that number to increase to about 4,500. This year's theme, "Space: the Power of the Past, the Promise of the Future," pays homage to the 50th anniversary of Apollo 11 while highlighting the collaborations that will be needed to achieve the next big accomplishment in space.

From brushing shoulders with agency heads to brushing up on the latest space trends, here's my personal "do-not-miss" list.

Opening Ceremony

Monday, Oct. 21, 9-10:30 a.m. in Grand Ballroom ABC

IAF will present its World Space Award posthumously to Neil Armstrong and to the surviving Apollo 11 crew members, Buzz Aldrin and Michael Collins. U.S. Vice President Mike Pence has been invited to attend and give remarks, but as of this writing, IAF did not know whether Pence, Aldrin and Collins would attend.

Space Agencies: Challenges and Opportunities in a Changing Space Environment

Monday, Oct. 21, 1:15-2:45 p.m. in Grand Ballroom ABC

This panel with heads of government space agencies provides broad context for the week's discussions. If all goes as planned, NASA Administrator Jim Bridenstine and the leaders of the Russian, Indian, French and Japanese space agencies will discuss the challenges and opportunities they see ahead for their countries, followed by a Q&A with attendees.

From Earth to the Moon and Mars: An Astronaut Roundtable

Monday, Oct. 21, 4:15-4:45 p.m. in Grand Ballroom ABC

Former NASA astronauts Charles Precourt, Kent Rominger and Robert Curbeam, now all of Northrop Grumman, will discuss lessons learned from previous space programs and how those might apply to future exploration efforts.

Exhibit Hall

Open 11-6 p.m. Monday, Oct. 21; open 9-6 p.m.

Tuesday-Thursday; open 9-5 p.m. Friday, Oct. 25.

What do the RS-25 engines for NASA's Space Launch



AT A GLANCE

WHAT: 70th International Astronautical Congress, hosted by the American Institute of Aeronautics and Astronautics

WHEN: Oct. 21-25

WHERE: Walter E. Washington Convention Center, Washington, D.C.

WHO: At least 3,000 attendees from 64 countries

WHERE TO GO: At least 225 companies and organizations on display in the 21,000-square-meter exhibit hall

WHAT ELSE: Find the program at www.iac2019.org

System rockets, Lockheed Martin's Martian habitat and Blue Origin's lunar lander have in common? They'll all be on display at IAC.

As of mid-September, about 250 companies had registered to fill the 20,438-square-meter exhibit hall (that's roughly four American football fields), making the congress one of the largest space exhibits in the U.S. this year.

The Long-Term Sustainability of Outer Space

Tuesday, Oct. 22, 8:30-9:30 a.m. in Grand Ballroom ABC

As the world becomes increasingly dependent on the growing number of satellites orbiting the Earth, protecting that technology becomes increasingly important as well. This panel on conserving space assets will kick off with a speech from Jeff Bezos, founder and CEO of Blue Origin. Bezos will also give remarks later that day at the Industry Luncheon, which is invite only, where he will accept the IAF Excellence in Industry Award on behalf of Blue Origin.

Global Networking Forum Storytelling Sessions

Tuesday, Oct. 22, 9:40-10:40 a.m. in Grand Ballroom AB

If you tire of panels and lectures, the GNF sessions offer more laid-back settings to hear from space professionals. In these quick sessions, Commercial Spaceflight Federation President Eric Stallmer will moderate 10-minute discussions with executives from Virgin Galactic, Blue Origin, Thales Alenia Space, Made in Space, Arianespace and SpaceX. Individual discussion times are listed in the program.

MARSIS: The Successful Search for Liquid Water on Mars

Tuesday, Oct. 22, 6-7 p.m. in Grand Ballroom B

Since the 1970s, orbiting spacecraft have found evidence Mars once contained water, but proof that liquid water was still present remained elusive. Then along came the Italian Space Agency's MARSIS, short for Mars Advanced Radar for Subsurface and Ionosphere Sounding. It scanned Mars' south pole from 2012 to 2015, discovering what seems to be a subsurface lake. Enrico Flamini, former chief scientist of the Italian Space Agency, will discuss this discovery in depth and how the sounding radar on MARSIS, co-developed by NASA, could be applied to future exploration of Mars and other planets.

Heads of Emerging Agencies

Wednesday, Oct. 23, 8:30-9:30 a.m. in Grand Ballroom B

For some countries, space is a fairly new endeavor, and that's why AIAA Local Organizing Committee co-chair Vincent Boles dubs this panel with the space chiefs of emerging space nations "one of the most attractive" events at IAC. Despite their small space

programs, "they're the nations that derive the most benefit from some of the attributes space can provide," like monitoring crops and other resources, Boles says. As they improve their technologies, these countries could be poised to make global contributions. The heads of the South African, United Arab Emirates, Nigerian, Brazilian and Thai space agencies will discuss these possibilities.

Space Traffic Management: Working Together to Enhance Safety and Sustainability

Wednesday, Oct. 23, 9:45-11:15 a.m. in Room 146A

The lack of geographic boundaries makes issues like space debris and collision avoidance "a world problem," AIAA Local Organizing Committee co-chair Vincent Boles says. As the number of space actors increases, so does the need for a space traffic management system to monitor and coordinate the paths of satellites, spacecraft and other objects on orbit.

This session will explore the legal and regulatory challenges with establishing space traffic management and the current technology for tracking and monitoring satellites and orbital debris.

Europa Clipper: Making a Mission to Understand Our Place in the Universe

Wednesday, Oct. 23, 1:30-2:30 p.m. in Grand Ballroom B

In 2025, if plans hold, a NASA spacecraft will be launched toward Jupiter to spend three years orbiting the planet's ice-covered moon Europa to see if its interior ocean could sustain life. The engineers and scientists working on the Clipper at NASA and the Johns Hopkins University Applied Physics Lab will be joined by Bill Nye of The Planetary Society in a discussion of challenges associated with the mission and the scientific questions Europa Clipper could answer.

IAF World Space Award Highlight Lecture

Thursday, Oct. 24, 6-7:15 p.m. in Grand Ballroom ABC

The recipient traditionally gives an in-depth lecture, but as of this writing, the details were still being finalized.

Public Day

Friday, Oct. 25. Doors open at 7:30 a.m.

IAF traditionally opens the venue and select events to the public, and this year is no exception. On the final day, visitors can tour the exhibit hall, watch a livestream with NASA astronauts aboard the International Space Station, and hear from the scientists and engineers building the next generation of rockets meant to carry astronauts and cargo to low Earth orbit and beyond. ★



Cat Hofacker

is the staff reporter for Aerospace America, where she is in charge of online news and on-site coverage of aerospace conferences and events.

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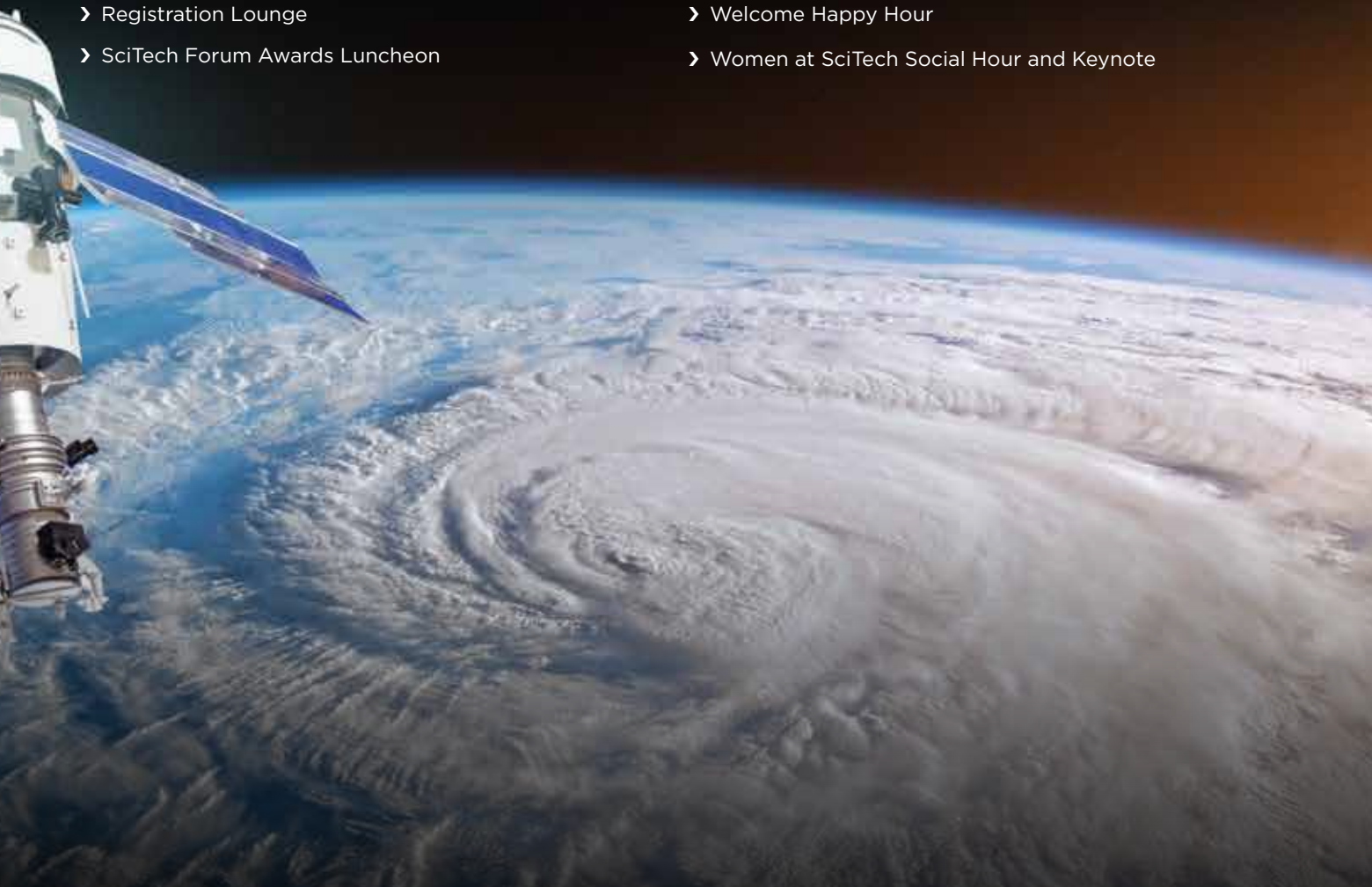
- › **Kevin Bowcutt**, The Boeing Company
- › **Simonetta Di Pippo**, United Nations
- › **Wesley Harris**, Massachusetts Institute of Technology
- › **Mark Lewis**, University of Maryland
- › **Robert Lightfoot**, Lockheed Martin Corporation
- › **AJ Piplica**, Hermeus
- › **Ellen Stofan**, National Air and Space Museum
- › **Graham Warwick**, Aviation Week & Space Technology
- › **Danielle Wood**, MIT Media Lab

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SUPERSONIC'S NOT-SO-SUPER EMISS

Those who want to revive supersonic passenger flight will need to do more than build Mach 1 aircraft. They'll need to convince a climate-change-rattled world that their comfort won't make the greenhouse gas problem a whole lot worse. The industry has some creative ideas for addressing the problem. **Adam Hadhazy** delves into them.

BY ADAM HADHAZY | adamhadhazy@gmail.com

SIONS

Life turned hard for supersonic enthusiasts at British Airways and Air France not long after they started flying Concorde in 1976 on regularly scheduled routes from London to Bahrain and Paris to Rio de Janeiro. Orders for the pioneering aircraft failed to materialize; instead of an anticipated fleet of hundreds, only 14 Concorde ever flew commercially. A ban on overland sonic booms in the United States, a major aviation market, limited the sound-barrier-busting aircraft to servicing a few American cities relatively close to coastlines. Maintenance and fuel costs continued to spiral far higher than expected. Capping a fraught 27-year run, the last Concorde took off from JFK airport and touched down at Heathrow in 2003, completing a final trans-Atlantic crossing.

Flash forward to 2019, and a new class of supersonic aircraft entrepreneurs — led by Aerion Supersonic of Nevada, Boom Supersonic of Colorado and Spike Aerospace of Massachusetts — has taken up the torch. All must deal with the overland supersonic ban and now also a hot issue that was not on the agenda in the Concorde's heyday: carbon emissions. The U.S., at least at the moment, has not made regulating carbon emissions from aircraft (or anything, really) a priority. But elsewhere, the aviation industry is under scrutiny for its small yet sizeable and growing greenhouse emissions, uniquely damaging because of their deposition at altitude.

Supersonic planes add to this challenge by flying higher and faster than their subsonic cousins. Cruising above 50,000 feet, exclusively in the stratosphere's thinner air, cuts down on heat-generating, airframe-stressing, and fuel-efficiency-eating resistance. Yet such heights pose new climate-warming emissions complications. Fundamentally, flying faster requires more energy and fuel burn, translating to greater emissions.

"We fully recognize that we are going to pump out more greenhouse gases than a subsonic aircraft will. That's just the laws of physics," says Gene Holloway, chief sustainability officer at Reno, Nevada-based Aerion.

The three companies plan to address the emissions challenge in several ways. The most straightforward — applying to subsonic aircraft too — is improving aerodynamics and developing more efficient engines. Switching from fossil-fuel-based, conventional jet fuel to alternative fuels with lower net life-cycle carbon emissions is another tactic. Aerion has further emphasized how considering its aircrafts' entire lifecycles, not just flight operations, will reduce carbon footprints. Meanwhile, both Aerion and Boom are angling for new, supersonic-specific environmental standards that are more permissive than

subsonic standards, acknowledging the supersonic sector's emissions potency.

Emissions could prove to be one of the harder nuts to crack for supersonics. Ongoing research into so-called low-boom technology by NASA and industry players, focusing on aerodynamic design, looks like it could downgrade a boom from a disruptive thunderclap to the soft thump of a car door closing. As for the root business case, all three supersonic companies also claim the demand is there for their product. Boom plans on a roughly 55-seater and says that ticket fares will be competitive with subsonic business-class seating. Aerion and Spike, meanwhile, are targeting deep-pocketed business jet owners willing to pay more to slash travel times. All companies are aiming for deliveries by the mid-2020s.

"What Concorde showed is there is a market for customers who want to reach destinations faster," says Vik Kachoria, CEO of Boston-based Spike. "What we need to figure out is how to do the Concorde, but we need to do it safer, more efficiently and more sustainably."

A growing impact

At present, aviation accounts (depending on methodology) for 2 to 3% of humanity's total greenhouse gas emissions. That share is expected to triple at a minimum by mid-century, according to ICAO, the United Nation's International Civil Aviation Organization, due to ever-increasing demand for air travel and more planes plying the skies. In just 20 years, the current worldwide fleet of circa 22,000 commercial aircraft is projected to double.

Airlines have gotten on board with emissions reductions, with all major carriers in the U.S. and most worldwide voluntarily committing to ICAO's Carbon Offsetting and Reduction Scheme for Inter-



national Aviation resolution, known as CORSIA. Established in 2016, CORSIA caps emissions at 2020 levels for international flights, which accounts for about two-thirds of aviation's carbon dioxide emissions; flights within a nation's borders are covered under the Paris Agreement, the U.N. climate accord reached in 2016, and national commitments. Starting in 2027, when CORSIA becomes mandatory for all 192 countries that are part of ICAO, airlines can stay under their cap on their country-to-country flight routes by buying offsets through carbon marketplaces. An example offset would be buying a carbon credit, equivalent to a 1,000 kilograms of carbon dioxide production, that helps pay for, say, installing a solar power array for a rural electrification project. Airlines are thus incentivized to fly lower-emissions aircraft to avoid the expense of exceeding the cap.

Supersonics could prove a challenge in that regard. Estimates widely vary, but faster-than-sound planes could generate between two-and-a-half to seven times the carbon emissions of comparable subsonic craft. The International Council on Clean Transportation, a Washington, D.C.-based nonprofit research group, put out a study in January 2019 that arrived at the higher end of that range. Dan Rutherford, director of aviation programs for the council, says the estimate stems from supersonics' higher emissions per passenger kilometer figures. Smaller passenger capacity planes mean more fuel burn per passenger, and a supersonic airliner probably would need to stop to refuel on trans-Pacific flights. Plus, the svelte supersonic jets could not carry belly cargo, as today's conventional airliners do along with passenger luggage, likely requiring additional subsonic flights to meet this cargo demand. "Just because of their speed, you'd expect

supersonics to burn about three times as much fuel as a comparable subsonic, and then from there you start adding other multipliers," says Rutherford.

Although the three supersonic companies plan to deliver only several hundred aircraft apiece, that's still a tremendous leap from those 14 Concorde that ever entered commercial service. For Rutherford, the exploding demand for conventional flights is bad enough without exacerbating those emissions with supersonic aircraft. "I've described this as 'when you're in a hole, stop digging,'" says Rutherford.

Making the Mach

When it comes to their part in aviation's climatic reckoning, Aerion, Boom and Spike each have unique supersonic speed targets, which in turn determine their aircraft development and emissions mitigation outlook.

Boom has based its business model on achieving Mach 2.2 cruise, about 2,700 kph (1,700 mph), or more than three times faster than a typical commercial plane flies today. That celerity would slash a typical seven-hour flight between New York and London to around three hours.

So far, Virgin Atlantic and Japan Airlines have preordered a combined 2½ dozen of Boom's proposed 55-seat, \$200 million airliner, called Overture. To help refine the aircraft's design and engineering, Boom is building a one-third-scale, two-seat demonstrator, the XB-1, nicknamed "Baby Boom." The first test flights are slated for next year, powered by three General Electric J85-15 military jet engines, the progenitors of the CJ610, a popular business jet engine.

Boom is working with undisclosed engine manufacturers to develop medium-bypass turbofan engines with greater efficiency than the afterburning turbojets that powered the first generation of

▼ **Spike Aerospace's** proposed 18-seat business jet, the S-512.
Spike Aerospace





▲ **Aerion's proposed** 12-seater, the AS2, in an illustration.

Aerion

supersonic airliners. "While turbofans have been powering subsonic airliners for years, only recently have they advanced enough to be viable on supersonic airplanes," says Steve Ogg, chief aerodynamicist for Boom.

Materials-wise, Boom wants to build airframes with carbon composites, in line with the current state-of-the-art. The Boeing 787 and Airbus A350 XWB both make extensive use of the material, which provides necessary strength but with about 20% less weight than conventional aluminum.

Other aerodynamical, fuel-saving efficiencies include wing extensions, called chines, that stretch toward an aircraft's nose. Chines boost lift and thus reduce the speed (and fuel burn) necessary during takeoff and landing, while contributing additional lift at cruise. Overture also tapers toward its aft cabin where the wings are thickest, tamping down

air disturbances incurred by significant changes in cross-sectional area. Finally, the wings are designed with a mild camber and a swept trailing edge, reducing drag and helping quiet the sonic boom.

Aerion's approach markedly differs from Boom's. The Aerion jet, dubbed the AS2 and with a sales price of \$120 million, will seat 12 and have a top speed of Mach 1.4. Where Aerion feels it has a technology edge over competitors is in engine design. Powering the AS2 will be three twin-shaft, twin-fan turbofan Affinity engines. Developed by GE Aviation and derived from the core found in F-16 fighter jets and the Boeing 737, it is undergoing final design for a prototype build in 2020. "We have the first supersonic engine in 55 years," says Aerion's Holloway. Also in Aerion's corner is Boeing, which inked a deal (funds undisclosed) in February to accelerate design and technology development. Lockheed Martin and



“What Concorde showed is there is a market for customers who want to reach destinations faster. What we need to figure out is how to do the Concorde, but we need to do it safer, more efficiently and more sustainably.”

— Spike CEO Vik Kachoria

pairing it with hydrogen, stripped from water, ultimately building up to usefully combustible hydrocarbons. Like biofuels, if manufactured with renewable energy, synthetic fuels would have an overall low carbon footprint, taking out of the air what gets put back in. Following through on that hope, Boom has partnered with a California startup, Prometheus Fuels, to produce carbon-neutral synthetic fuel for the XB-1 demonstrator.

Alternative fuels still have quite a way to go, though. Rutherford, the supersonics skeptic, says the International Air Transport Association and airframe manufacturers “have made getting renewable jet fuel their main environmental priority over the last 10 years.” A decade ago, rosy predictions put biofuel penetration, for instance, as high as 10% by 2020. Rutherford says the actual percentage has worked out to be less than a hundredth of a percent currently, due in large part to biofuels not being cost-competitive with conventional jet fuel. “Biofuels haven’t scaled, costs have not come down, and to date it hasn’t worked,” he laments.

Aerion’s Holloway acknowledges the issue but points to the deep interest in alternative fuel development internationally, improving yields with new feedstock types from algae to municipal waste.

Alternative fuels could also be engineered to have more favorable emissions profiles. Typical jet fuel, when burned, produces emissions composed of about 70% carbon dioxide and a shade under 30% water vapor — both heat-trapping greenhouse gases. Those two products are more or less inevitable. But the trace remainder of other emissions offers significant opportunities for reductions. These traces, consisting of carbon monoxide, nitrogen oxides (NOx), oxides of sulfur and volatile organic compounds, all have indirect warming effects as they interact with atmospheric gases. NOx, for instance, produces the greenhouse gas ozone in the troposphere, the lowest part of the atmosphere that ends at about 20 kilometers (65,000 feet) around the equator down to 7 k (23,000 feet) at the poles. Depending on the chemistry of their feedstocks, some biofuels produce fewer NOx emissions because they contain fewer nitrogen compounds, thus im-

Airbus had both previously worked with Aerion, going back to 2014.

Spike Aerospace splits some of the differences between Boom and Aerion, opting for Mach 1.6 from its proposed 18-seater business jet, the S-512. Many details regarding Spike’s industry partners, let alone emissions mitigation, have not been made public, though Kachoria says announcements will be made possibly before the close of 2019.

What’s in the tank?

Fuel will, of course, factor prominently into how the supersonic sector addresses its emissions. All the companies have expressed interest in having their products fly on alternative fuels. That category includes familiar biofuels, derived from a living feedstock, as well as synthetic fuels. These are made from pulling carbon dioxide out of the air and



proving the overall emissions profile of the jets they power.

Specks and clouds

Particulates represent another set of nasties from fossil fuel combustion that innovation could address. One particularly potent component is black carbon, or soot, which, unlike gaseous carbon dioxide, absorbs and then re-radiates sunlight. “Per unit mass, black carbon is a million times more powerful than CO₂ at warming the air,” says Mark Z. Jacobson, a professor of civil and environmental engineering at Stanford University who studies fossil fuels and air pollution. With supersonic flight, deposition of black carbon at high altitudes is especially worrisome. Most soot, produced by vehicle emissions, rains out of the atmosphere in a week, Jacobson says. In the stable stratosphere, where air does not rise or sink, particles could linger for months, even years. “You’re injecting all these particles into the stratosphere, and they’re going to stay there a long time,” says Jacobson.

Emitted particles, provided there is enough water vapor, also contribute to contrail formation. Each particle provides a mote upon which water vapor condenses and freezes, creating the picturesque cirrus clouds that trail airplanes when atmospheric conditions are right. Pretty as they can be at sunset, these high-altitude clouds pose a problem, climatically speaking. Contrails reflect infrared radiation back toward the ground, with studies suggesting they trigger as much warming as aviation’s carbon dioxide emissions.

There is disagreement about whether the altitudes supersonics would fly at would add to the jets’ environmental impact, indicative of the still-unsettled science about conditions affecting contrail formation, duration and impact. [See “Curbing Contrails” from the Aerospace America February 2016 issue]. One agreed-upon advantage, though, is the lower humid-

▲ **Three twin-shaft,** twin-fan turbofan Affinity engines will power Aerion’s AS2 jet.

GE Aviation

ity compared to subsonic cruise altitudes. “That’s good news for keeping contrail generation and cirrus clouds down,” says Jonathan Seidel, chief engineer in the Propulsion Systems Analysis Branch at NASA’s Glenn Research Center in Ohio, who studies supersonic flight. The downside at these rarefied altitudes, though, is that there is little atmospheric mixing to dissipate contrails. “While formation should be less, they’re likelier to persist longer,” says Seidel.

Other atmospheric scientists, and the supersonic companies themselves, think contrail formation will be minimal. “In my opinion, the humidity is really too low to form contrails,” says Andrew Gettelman, an atmospheric scientist at the National Center for Atmospheric Research in Boulder, Colorado.

Cleaner burning engine combustors, which would devote more air intake to the combustion process itself and less to cooling, would further squeeze emissions improvements from choice fuels. “You’re burning in a much leaner fuel-to-air ratio to control the formation of various emission components,” says Peter Coen, the mission manager for NASA’s Low-Boom Flight Demonstration mission, geared toward aerodynamically quieting sonic booms and overall advancing supersonic commercial flight. Another attractive technology, Coen says: making the combustor from innovative high-temperature materials that would up the operating temperature for more thorough combustion.

Beyond the airframe

Sleek aerodynamics, alternative fuel and the latest technologies may not be enough for substantial, sufficient emission reductions. Supersonic flight’s backers are therefore advocating for new emission standards tailored to their vehicles, allowing time for further advancement — not unlike the efficiencies gained over decades of conventional aircraft refine-



ment. “Subsonic engines have enjoyed 60 years of development, going back to the [Boeing] 707’s introduction,” says Aerion’s Holloway.

Holloway’s company is working with subgroups of ICAO’s technical committee on aviation environmental protection to formulate supersonic emissions standards. Policymakers and manufacturers trying to quantify the problem have the Concorde as their starting reference point. Flying at Mach 2, it pumped out about three times as much carbon dioxide and NOx as subsonics. Factoring in its 60,000-foot cruising altitude, the Concorde overall had about a five-fold stronger climate impact.

Today’s carbon standards rely on a “tank to tailpipe” model that specifies an allowable amount of emissions from the aircraft. One way to accommodate supersonic airplanes would be to shift to considering not just those emissions but also the entire life cycle of a plane. This “well to wake” approach wraps in everything from the origins of a plane’s fuel (like from an oil well) to how emissions chemically interact with the atmosphere in the plane’s wake and beyond, rather than just focusing on the bulk amount of carbon dioxide released. “If the world is going to judge us on a tank-to-tailpipe basis, we will never win that battle,” says Holloway.

“We’re looking at it from the standpoint of what can we do in the design and manufacturing of our jet that also reduces our carbon footprint overall.”

That standards approach could extend to materials on the plane, for instance recycled (and ultimately re-recyclable) plastics for floors, seat frames and other interior elements. Aerion could opt for suppliers of parts that have environmentally friendly certifications, such as green-building ratings from LEED, for Leadership in Energy and Environmental Design. Also compensating for aviation-related emissions could be companywide initiatives in matters unrelated to aviation, such as office energy use.

“The push-and-pull right now about environmental standards is important,” says Rutherford, who is also a technical observer at ICAO on climate matters. “It will fundamentally influence where the money flows and what type of aircraft may or may not be built.”

Indeed, for supersonic airplanes, the “what” does not loom so much as an issue, but the “how.”

“Flying supersonic itself is not very difficult,” says Holloway. “The real challenge is flying supersonic at scale while also meeting environmental standards.” ★

▲ **Boom’s proposed jet,** the Overture.

Boom Supersonic

The background is a dark, deep blue space filled with a complex network of thin, glowing lines in shades of blue and purple. These lines form a web-like structure, with some areas appearing denser than others. Scattered throughout this network are various financial symbols, including dollar signs (\$), Bitcoin symbols (B with two vertical lines), and Euro symbols (€). The symbols are rendered in a semi-transparent, glowing style, blending with the network lines. At the bottom of the image, there is a dark, silhouetted horizon line that suggests a mountain range or a distant landscape under a twilight sky. The overall aesthetic is futuristic and digital, emphasizing themes of global connectivity, finance, and technology.

Relations reboot



The space domain's new status as a promising field for investment is shaking up long-standing relationships among governments, startups and corporations. Debra Werner chronicles the seismic shifts underway in the satellite market.

BY DEBRA WERNER | werner.debra@gmail.com

Startups and established players in the global space industry are vying for big dollars. Specifically, \$1 trillion or more a year. That's how high the annual value of goods and services produced globally by the industry is expected to grow by 2040, according to independent estimates by Bank of America, Merrill Lynch, Goldman Sachs and Morgan Stanley.

In the U.S. specifically, that growth potential is forcing entirely new relationships to form among governments, commercial players and potentially millions of consumers involved in satellite communications and imaging.

"We are in the middle of a very significant transformation from a time when government was responsible for almost everything happening in space to private industry playing an increasingly important role," notes George Nield, who retired last year as the head of the FAA's Commercial Space Transportation Office, which licenses rocket launches by U.S. companies and flights from U.S. spaceports.

Radar startups

Consider a market such as the nascent one for commercially produced radar imagery. This kind of imagery was pioneered by government agencies including the Canadian Space Agency, the U.S. Air Force, the National Reconnaissance Office spy satellite agency and NASA. Aircraft, oceans, storm-damaged islands and a host of phenomena can be observed through clouds or darkness. Startups in the field often like to woo investors by emphasizing new commercial markets over these traditional government ones.

Occasionally, reality creeps into the discussion, such as in an exchange I witnessed at a space industry conference in Paris last year.

In a Westin hotel ballroom, a reporter asked panelist Rafal Modrzewski, the CEO of Iceye of Finland, about customers for its synthetic aperture radar satellite. When Modrzewski said govern-

ment agencies around the world would be the biggest customers for the radar imagery, another radar entrepreneur, Capella Space CEO Payam Banazadeh, said in mock surprise: “Oh, are we telling the truth? That’s OK, the investors aren’t here.”

The joke was a reference to the sector’s bold predictions that insurance companies will want to assess millions of claims with the aid of radar imagery, and multinational corporations will decide to keep tabs on far-flung facilities day and night. These predictions could prove to be right, but in reality commercial markets for radar imagery are just starting to develop. At this year’s World Satellite BusinessWeek last month, Banazadeh acknowledged as much to an audience, saying, “We are now openly talking about the elephant in the room,” he said. “You can’t be in this business unless you are doing serious business with the government.”

A challenge for nongovernment customers is that radar images require expert analysis or sophisticated software to make them easier to decipher. For now, military and intelligence agencies remain the world’s largest consumers of radar satellite data.

Like the forthcoming commercial customers, those government customers are eager to take advantage of the low cost and high revisit rate of small commercial satellites. Until now, radar satellites have tended to be large and expensive. The NRO in 2009 declassified the fact that it conducts radar satellite reconnaissance. The Canadian Space Agency launched a trio of car-size satellites in June for its Radarsat Constellation Mission as a successor to the Radarsat-1 satellite launched in 1995 and to join Radarsat-2 launched in 2007.

By contrast, the commercial radar satellites are closer to the size of miniature refrigerators and can cost as little as \$3 million to build and launch, said U.S. Air Force Col. Steve “Bucky” Butow, at the Space Tech Expo in Pasadena, California, earlier this year. Butow is the space portfolio director for the Defense Innovation Unit, a Pentagon agency focused on solving national security problems with commercial technology. “The idea is that as we migrate to smaller, less expensive satellite buses, we can build larger constellations and look at patterns of life changes,” Butow said.

While the consumer side of the radar market is evolving, companies aren’t always upfront with potential investors about the fact that governments will remain important customers because of their deep pockets and familiarity with the product.

Global internet services

The interplay between governments and corporations in the satellite communications field shows a slightly different dynamic from that of space-based radar. Half a dozen companies plan to launch or have begun

“We are in the middle of a very significant transformation from a time when government was responsible for almost everything happening in space to private industry playing an increasingly important role.”

— George Nield, formerly of FAA

launching constellations to provide internet access to consumers anywhere on the globe. Unlike the case with radar, private-sector entities are the pioneers. Leading the way are SpaceX and the OneWeb startup based in London. They have begun launching rival constellations that will serve commercial customers in the long term even if U.S. government agencies could be among their anchor customers. The U.S. military is eager to explore, for example, whether soldiers could make telephone calls and access the internet from mobile devices on distant battlefields with the help of these commercial satellites that are also about the size of mini refrigerators.

U.S. government agencies also are providing early research dollars and experiment opportunities for one of the dozen or so companies that are competing to create a cubesat-based internet of things. The constellations would track or link cars, trucks, computers and a host of other objects anywhere in the world. The National Science Foundation, for example, is aiding Swarm Technologies, a Silicon Valley startup, with tests of its tracking and messaging service over the four hockey-puck-size SpaceBee satellites the company launched in 2018. Each SpaceBee is a one-quarter cubesat so that four can be launched from a standard cubesat dispenser. On the ground, smartphone-sized messaging devices and trackers would be attached to cars, trucks, computers or anything else a consumer might want to link to the internet. For its part, the National Science Foundation wants to learn whether scientists in Antarctica could share their data with far-flung scientists over Swarm’s network.

Cultural shifts

This dynamic in the communications and imaging markets is requiring U.S. government agencies to reboot their acquisition culture. For decades, government agencies described in detail the capabilities they wanted from their next satellite before turning to a stable of government contractors to produce them. Managers tended to load on requirements and secondary payloads on satellites destined for



orbit, which meant the satellites often were the size of cars, trucks or even school buses. Inevitably, the government customer had to wait years for delivery.

Now, in addition to weighing service options, agencies are experimenting with ordering the same mini-refrigerator-size satellites that their commercial brethren buy. The U.S. Army Space and Missile Systems Command launched in May a commercial radar satellite built by York Space Systems. York is a Denver startup preparing to mass manufacture satellites that sell for \$1.2 million.

It's all part of a new strategy of buying commercial products and services instead of products designed specifically for government customers.

The U.S. Defense Innovation Unit, or DIU, talks about problems military units face and asks companies to propose commercial solutions to solve them. Then, DIU has "the flexibility of combining commercial solutions from different companies to achieve a solution more rapidly than if we tried to invent it ourselves," Butow said by email.

Meanwhile, DARPA is holding a competition to see who in the private sector can launch small satellites on commercial rockets rather than those built to government specifications. If all goes according to plan, companies will attempt two launches weeks apart in 2020 from different launch sites as part of the DARPA Launch Challenge.

The NRO is evaluating commercial electro-optical satellite imagery gathered by BlackSky, Planet and Maxar with the idea of sharing the imagery with U.S. defense and intelligence agencies. "These companies are very dynamic," Peter Muend, director of NRO's Commercial Systems Program Office, said at the GEOINT conference in San Antonio in June. "They are bringing on new capability all the time."

NASA Administrator Jim Bridenstine offered a

similar message in August while touring Made in Space, a Silicon Valley startup focused on additive manufacturing in orbit. "NASA doesn't want to be the purchaser, the owner and the operator of all of the hardware and the equipment," Bridenstine said. "We have a vision, especially in low Earth orbit where NASA is ... one of many customers."

Ample investment dollars

The U.S. government no longer wants to call all the shots partly because private investment is flooding the space industry. In 2018 alone, investors provided \$3.2 billion to startups around the world, with U.S. firms accounting for about 80% of the money, according to "Start-Up Space: Update on Investment in Commercial Space," a report published in April by Bryce Space and Technology, an Arlington, Virginia, engineering and analysis firm.

Space companies also are benefiting from investments by car and mobile phone companies on technologies for shrinking electronics and increasing automation. This has created a dynamic marketplace with new space companies popping up weekly to offer everything from shoebox-sized weather satellites to methane monitoring sensors and techniques for pinpointing ships by homing in on their radio frequency signals.

Space industry entrepreneurs see dozens of current and potential markets developing. In addition to launching satellites and transporting cargo and crew to the International Space Station, companies are raising money to build private space stations, where customers could conduct pharmaceutical research and 3D print materials. Firms are testing technologies to refuel or repair satellites in orbit and, in some cases, move defunct satellites out of orbit. Virgin Galactic and Blue Origin plan to send

▲ **Earth was visible** through the windows of Blue Origin's New Shepard vehicle in January as it carried eight research projects through space as part of NASA's Flight Opportunities program.

Blue Origin



tourists on suborbital flights in 2020 with spacecraft that could eventually transport passengers into Earth orbit or on quick flights from the United States to Asia. Decades from now, space companies may even be collecting water from the moon or asteroids and turning it into rocket fuel.

In the near term, the majority of commercial space products and services focus on Earth observation and communications. Consumers around the world spent \$124.4 billion on satellite communications last year, including telephone, television, radio and broadband. They spent another \$2.1 billion on remote sensing, such as Earth imagery to gauge crop health, track wildfires and forecast the weather, according to “2019 State of the Satellite Industry,” an annual review of the global market published by the Satellite Industry Association in Washington, D.C. Companies are selling small satellites to perform those jobs as well as cameras, synthetic aperture radars, batteries and technology to relay communications and imagery between satellites and from satellites to the ground.

The space industry’s most famous entrepreneurs, SpaceX/Tesla founder Elon Musk and Amazon/Blue Origin founder Jeff Bezos, are betting heavily on communications. Bezos is preparing to send thousands of satellites into low Earth orbit to establish multibillion-dollar constellations offering global telephone and internet access.

Gordon Roesler, who retired from DARPA last year and established Robots in Space, an Annapolis, Maryland, consulting firm, says if demand for communications bandwidth keeps climbing as it has for years, it will take all those satellites and then some “to support higher definition television, communications in developed countries and simple internet in developing nations.” Plus, U.S. government agencies want to take advantage of the new constellations to address their own surging demand for global voice, video and text communications.

At DARPA, Roesler led the Robotic Servicing of Geosynchronous Satellites program, an effort to develop and demonstrate technologies in orbit. DARPA’s goal is to prove the technology and then hand it off to a company that will begin inspecting and repairing satellites for government and com-

mercial customers. Bringing new technologies to the point where the private sector can “take the technology and run with it” is an important government mission, Roesler says.

The U.S. government also remains a valuable customer for space startups, particularly when it signals clear and consistent priorities, says Dylan Taylor, a space industry investor and co-founder of Space Angels Network, a New York company that invests in early stage space companies. “Where the market struggles a bit is when it’s trying to figure out what clients want,” he says. “Obviously the government is a big client.”

Nield, the former FAA official, sees government as an investor and partner for the commercial space industry, helping to maintain national security and public safety and establishing regulations that give investors and spacecraft operators confidence in the market. Much of that already happens. The FAA licenses rocket launches and satellite reentries. The Federal Communications Commission establishes rules for radio broadcasts from space, and NOAA licenses remote sensing satellites.

When it comes to space traffic management, outside experts and government managers in the U.S. continue to argue among themselves about which roles government and industry should play. For now, the U.S. military tracks satellites and warns operators of potential collisions. The Trump administration and Congress are eager to transfer that job to a civil agency, either the FAA or the Commerce Department, but can’t agree on which one.

Even if the U.S. and other space-faring nations fail to come up with a clear plan for managing space traffic, Roesler is confident industry could solve the problem on its own. In an industry solution, “perhaps not all the i’s would be dotted, and the t’s crossed, but it would be workable,” he says.

The world’s largest satellite fleet operators already share information on the location of their satellites and contact one another before taking evasive maneuvers through the Space Data Association, an industry group established in 2009 in Luxembourg. “You can imagine that growing to deal with all of the space traffic,” Roesler says. ★

▲ **Small satellites**

like the one in this rendering would form a radar imaging constellation for Capella Space of California.

Capella Space

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- Driving aerospace improvement initiatives to yield business results

Key Speakers



Jim McClelland

Chief Technology Innovation Officer
Airbus Defense and Space, Inc.



Brenda Boorda

VP, Mission Assurance, Space and Airborne Systems
Raytheon



Colonel Shawn McCamish, USAF, Ph.D

Commander
DCMA Lockheed Martin Sunnyvale



Chris Kmetz

VP, Engineering, Module Centers
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Artemis must learn from Apollo

The Apollo program proved to be unsustainable. If NASA and the Trump White House want to avoid the same fate for their Artemis lunar program, they should learn from Apollo's history. Space historian **John Logsdon** shares some of the lessons he sees. BY JOHN M. LOGSDON



▲ **Orion's European Service Module** at Kennedy Space Center in Florida. Eleven countries contributed to building the service module, which will supply electricity, water, oxygen and nitrogen to the spacecraft.
NASA/Rad Sinyak

The siblings Apollo and Artemis are not only related in Greek mythology. The outcome of NASA's proposed Artemis lunar program will determine whether 500 years from now humanity's first step on the moon will indeed mark the 20th century as "the century when we began the exploration of space," as American historian and Kennedy adviser and biographer Arthur Schlesinger Jr. once predicted, or whether Apollo 11 may be remembered as a glorious moment "without lasting significance," as former NASA chief historian Roger Launius warns in "Apollo's Legacy," his book timed to coincide with the 50th anniversary of the moon landing.

Failure to sustain the Artemis program, coming on the heels of previous unsuccessful attempts in 1989 and 2004 to initiate a government-led human space exploration program, would lend credence to Launius' assessment.

Despite the many difficulties that surely lie ahead, the U.S. is closer today, both technically and politically, to returning Americans to the moon than at any point since Apollo 17 left the lunar surface in December 1972. But success in that effort is far from guaranteed. Lessons relevant to the success of Artemis should be drawn from the Apollo experience. Learning from the initial lunar landing program is important to continuing today's momentum and, in the process, giving lasting significance to Apollo.

Build for the future

One lesson is that hardware must be developed with sustainability in mind. The Apollo program's overriding focus on meeting President John Kennedy's "before this decade is out" goal had unfortunate consequences for the future of the U.S. human spaceflight program. The Apollo elements were optimized for carrying people to the lunar surface at the earliest possible moment, and obviously were successful in that endeavor. But the combination of the Saturn V rocket and the Apollo spacecraft turned out to be not well-suited for a sustainable program of space development and exploration. The complex Saturn V was extremely expensive to produce and operate. While the Apollo command and service spacecraft could have served as a versatile though expensive space transportation system, the lunar excursion module was designed for the single purpose of carrying two astronauts between lunar orbit and the lunar surface. Its fragility, small size and limited cargo-and-crew-carrying capacity made it unsuitable for other post-Apollo uses. In addition, the Saturn/Apollo system posed more safety risks than some top NASA managers found comfortable. For example, soon after Apollo 11, Robert Gilruth, the head of the Manned Spacecraft Center in Houston, pushed for ending Apollo flights to the moon "before we lose someone."

NASA's original plans called for nine more Apollo landings after Apollo 11, but that plan began to unravel just six months after Neil Armstrong's historic footstep. In January 1970, the Apollo 20 mission was canceled, and its Saturn V booster re-assigned to the Skylab space station effort. Then, in September, after problems with the Apollo 13 flight, NASA proposed canceling two of the remaining six missions on both cost-saving and risk-avoidance grounds. The Nixon White House, spooked by the close call of Apollo 13, quickly accepted NASA's proposal. Nixon even suggested canceling the final two Apollo missions, but was persuaded not to pursue this course. Nixon correctly predicted as Apollo 17 left the moon in December 1972 that it would be "the last time in this century that men will walk on the moon."

The U.S. basically started over on human spaceflight with the 1972 decision to develop the space shuttle as the major post-Apollo program and then the 1984 decision to build a space station. Apollo hardware became museum exhibits, reminding us of a great achievement that was not soon to be repeated.

If Artemis is to avoid the dead-ended fate of Apollo, it is essential that the push to get two Americans back to the moon by 2024 not lead to the kind of system and hardware decisions that made Apollo unsustainable. The launch vehicle and spacecraft designs must be capable of sustainable, affordable operation at an acceptable level of risk, rather than simply being designed to meet the 2024 goal. Not giving adequate consideration to long-term operability is to ignore the Apollo experience.

Adapting for Artemis

To carry out Apollo, the U.S. mobilized a space-industrial complex centered on NASA and its major contractors. That complex remains in existence today, both as an essential element of U.S. space competence and a barrier to the institutional and management innovation necessary to make Artemis a success. The key decisions about how to meet Kennedy's "before this decade is out" deadline were made by NASA, with the space agency closely managing its contractors as they built the hardware NASA had designed. NASA engaged its congressional overseers in a partnership in which it had the freedom to make technical decisions in return for distributing the resulting work to key states and congressional districts.

This NASA-centric approach was key to Apollo's success, but it is ill-fitted for Artemis. In recent years, as the competence and creativity of the U.S. private space sector has grown, NASA, grudgingly, has begun to accept less control over execution of its human spaceflight programs. But NASA's traditional

contractors are pushing for continued support rather than sharing the workload with new entrants, and key members of Congress have been less than willing to allow the space agency the flexibility to pursue what it judges to be the best path to program success. One example of this behavior was Congress specifying in NASA's 2010 authorization bill the performance characteristics for the heavy-lift booster NASA was to develop; the result was the Space Launch System. More recently, decisions regarding the distribution of work for the Artemis lunar lander may be another example of not giving NASA the flexibility needed for success. Finding the appropriate balance between

▼ **The launch of the** Saturn V rocket carrying the Apollo 14 spacecraft on Jan. 31, 1971. The combination of the Saturn V rocket and the Apollo spacecraft turned out to be not well-suited for a sustainable program of space development and exploration.

NASA

a continuing key role for an evolved NASA and the contributions of both old and new entrants in the U.S. private sector is essential for U.S. leadership in sustained space exploration.

Wanted: geopolitical clarity

Government-directed human spaceflight programs are in their essence foreign policy initiatives, intended to send a message of national power to the rest of the world. Apollo had a clarity of geopolitical purpose that is so far lacking in Artemis. Apollo was aimed at signaling overall U.S. leadership in the Cold War competition with the Soviet Union. Kennedy's decision to go to the moon had little to do with future space exploration; rather, he chose to use the space program to pursue broader national and domestic political purposes. In announcing his decision in May 1961, he suggested that it was "time for this nation to take a clearly leading role in space achievement," noting that he was proposing to send Americans to the moon primarily because "no single space project in this time period will be more impressive to mankind." Speaking at Rice University in September 1962, Kennedy suggested that "no nation which expects to be the leader of other nations can expect to stay behind in this race for space." A few months later he told his space advisers "the Soviet Union has made this [space leadership] a test of the system. So that's why we're doing it," adding that Apollo "is important for political reasons, international political reasons."

In terms of its clearly stated foreign policy objective, Apollo was a remarkable success, both as it happened and even today. Much had changed in the U.S.-Soviet relationship by the time Armstrong stepped on the lunar surface, but that achievement, as Kennedy had intended, was indeed "impressive to mankind." There was no doubt after the lunar landing that the U.S. had become the leader in space. The accompanying prestige became a positive soft power asset underpinning the U.S. position in the world, both in 1969 and in the years to follow. The worldwide enthusiasm during this year's celebrations of the Apollo 11 50th anniversary suggests that the reputational payoffs from the moon program linger even after half a century. Apollo remains a success story in the use of space achievement as a tool of American diplomacy.

Demonstrating U.S. global leadership is once again being put forward as a leading reason for returning to the moon. But how best to achieve such a demonstration will be a challenge. Apollo was a unilateral undertaking, with NASA in the command role. Apollo's success was clearly an American achievement.

The approach to Artemis must necessarily be different, given other countries' ambitions and





increasing competence. At the March 2019 National Space Council meeting, chairman Vice President Mike Pence suggested, “We’re in a space race today, just as we were in the 1960s, and the stakes are even higher.” He added, “Last December, China became the first nation to land on the far side of the moon and revealed their ambition to seize the lunar strategic high ground and become the world’s preeminent spacefaring nation.” But it is not just China that has space leadership ambitions. Other spacefaring countries are also interested in lunar exploration and exploitation. If the U.S. is to maintain a space leadership position, engaging others in Artemis is essential.

The U.S. is not today in a two-entry space race, as was the case during Apollo; instead, it must operate in an environment that mixes competition and cooperation. At the Aug. 20 Space Council meeting, Pence declared, “The National Space Council today will send new policy recommendations to the president that will help drive even greater cooperation between our government ... and like-minded nations across the world — nations that share our values of democracy, freedom and the rule of law.”

Turning that rhetoric into reality will require creative diplomacy to create a long-term cooperative international strategy that other nations will embrace.

If Artemis is to have lasting geopolitical benefits similar to those that are part of the Apollo legacy, the U.S. will have to earn its leadership.

Beyond unilateralism

NASA’s exploration planning has in recent months focused on the largely unilateral U.S. effort to get back to the moon by the end of 2024. That effort has echoes of Apollo in its emphasis on getting two Americans to the lunar surface for a short stay. Plans for missions beyond the 2024 landing, and the role of international partners in those missions, are not yet clear. When, even if, the transition to the proposed multination approach will emerge is uncertain. There could well be a temptation to continue with a U.S.-dominant approach, avoiding the hard negotiations and compromises required to create an international space exploration coalition, with the United States as lead partner, but with significant contributions from other nations.

Such a coalition is the best path to success in human space exploration. The December 2017 Space Policy Directive-1 calls for NASA to lead “an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system.” If that objective is met, Apollo, as the first step in that expansion, will indeed go down, not only as a magnificent achievement, but also as a milestone in human history. ★

▲ **A Space Launch System** rocket in an artist’s concept.
NASA



John M. Logsdon

is professor emeritus at George Washington University and has written books on the space policies of U.S. Presidents Kennedy, Nixon and Reagan. He founded GW’s Space Policy Institute in 1987 and directed it until 2008. He is editor of “The Penguin Book of Outer Space Exploration.”

DEFENSE FORUM

5-7 MAY
2020
LAUREL, MD

The AIAA DEFENSE Forum brings together the contractor, acquisition, and R&D communities for classified discussions of critical technical, programmatic, and policy topics in a SECRET/NoFORN environment.

Participate in the 2020 technical briefings by submitting an abstract on one of the following topics:

- › Advanced Prototypes
- › Autonomy and Machine Intelligence
- › Computing Systems
- › Directed Energy Weapons
- › Guidance, Navigation, Control, and Estimation
- › Hypersonic Systems and Technologies
- › Missile Defense
- › Modeling and Simulation of Warhead Effects
- › Robotic and Unmanned Weapon Systems
- › Space Systems
- › Strategic Missile Systems – Ground-Based & Sea-Based Deterrent Systems
- › Survivability
- › System and Decision Analysis for National Security
- › Tactical Missiles
- › Weapon System Effectiveness – Operational Performance
- › Weapon System Effectiveness – Performance Analysis, Modeling & Simulation
- › Weapon System Effectiveness – Test and Evaluation

Abstracts due 8 October 2019

aiaa.org/defense

AIAA Bulletin

DIRECTORY

AIAA Headquarters / 12700 Sunrise Valley Drive, Suite 200 / Reston, VA 20191-5807 / aiaa.org

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

Example: christinew@aiaa.org.

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

Other Important Numbers: Aerospace America / Karen Small, ext. 7569 • AIAA Bulletin / Christine Williams, ext. 7575 • AIAA Foundation / Merrie Scott, ext. 7530 • Book Sales / 800.682.AIAA or 703.661.1595, Dept. 415 • Communications / John Blacksten, ext. 7532 • Continuing Education / Jason Cole, ext. 7596 • Corporate Members / Tobey Jackson, ext. 7570 • Editorial, Books and Journals / Heather Brennan, ext. 7568 • Exhibits and Sponsorship / Chris Semon, ext. 7510 • Honors and Awards / Patricia Carr, ext. 7523 • Journal Subscriptions, Member / 800.639.AIAA • Journal Subscriptions, Institutional / Online Archive Subscriptions / Michele Dominiak, ext. 7531 • Media Relations / John Blacksten, ext. 7532 • Public Policy / Steve Sidorek, ext. 7541 • Section Activities / Emily Springer, ext. 7533 • Standards, Domestic / Hilary Woehrle, ext. 7546 • Standards, International / Nick Tongson, ext. 7515 • Student Programs / Rachel Dowdy, ext. 7577 • Technical Committees / Emily Springer, ext. 7533

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

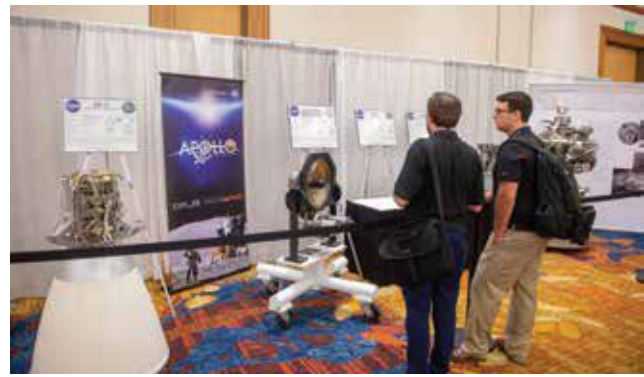
DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2019			
3 Oct–21 Nov	Fundamentals of Space Vehicle Guidance, Control, and Astrodynamics Short Course	Virtual (aiaa.org/onlinelearning)	
21–24 Oct*	International Telemetry Conference (ITC)	Las Vegas, NV (telemetry.org)	
21–25 Oct*	70th International Astronautical Congress	Washington, DC	28 Feb 19
2020			
4–5 Jan	3rd Sonic Boom Workshop	Orlando, FL	
4–5 Jan	Design of Experiments: Improved Experimental Methods in Aerospace Testing Course	Orlando, FL	
4–5 Jan	Design of Electrified Propulsion Aircraft Course	Orlando, FL	
4–5 Jan	Fundamentals of Drones: UAV Concepts, Designs and Technologies Course	Orlando, FL	
4–5 Jan	Integrated CubeSat Engineering	Orlando, FL	
4–5 Jan	Integrating Program Management, Systems Engineering, and Six Sigma	Orlando, FL	
4–5 Jan	Missile Guidance Course	Orlando, FL	
4–5 Jan	Systems Thinking for Modern Aerospace Complexity	Orlando, FL	
5 Jan	75+ Years of Hypersonics Development: History, Resources, References, and Insights	Orlando, FL	
5 Jan	Additive Manufacturing: Structural and Material Optimization Course	Orlando, FL	
5 Jan	Introduction to Digital Engineering Course	Orlando, FL	
5 Jan	Space Standards and Architecture	Orlando, FL	
5 Jan	A Unified Approach for Computational Aeroelasticity Course	Orlando, FL	

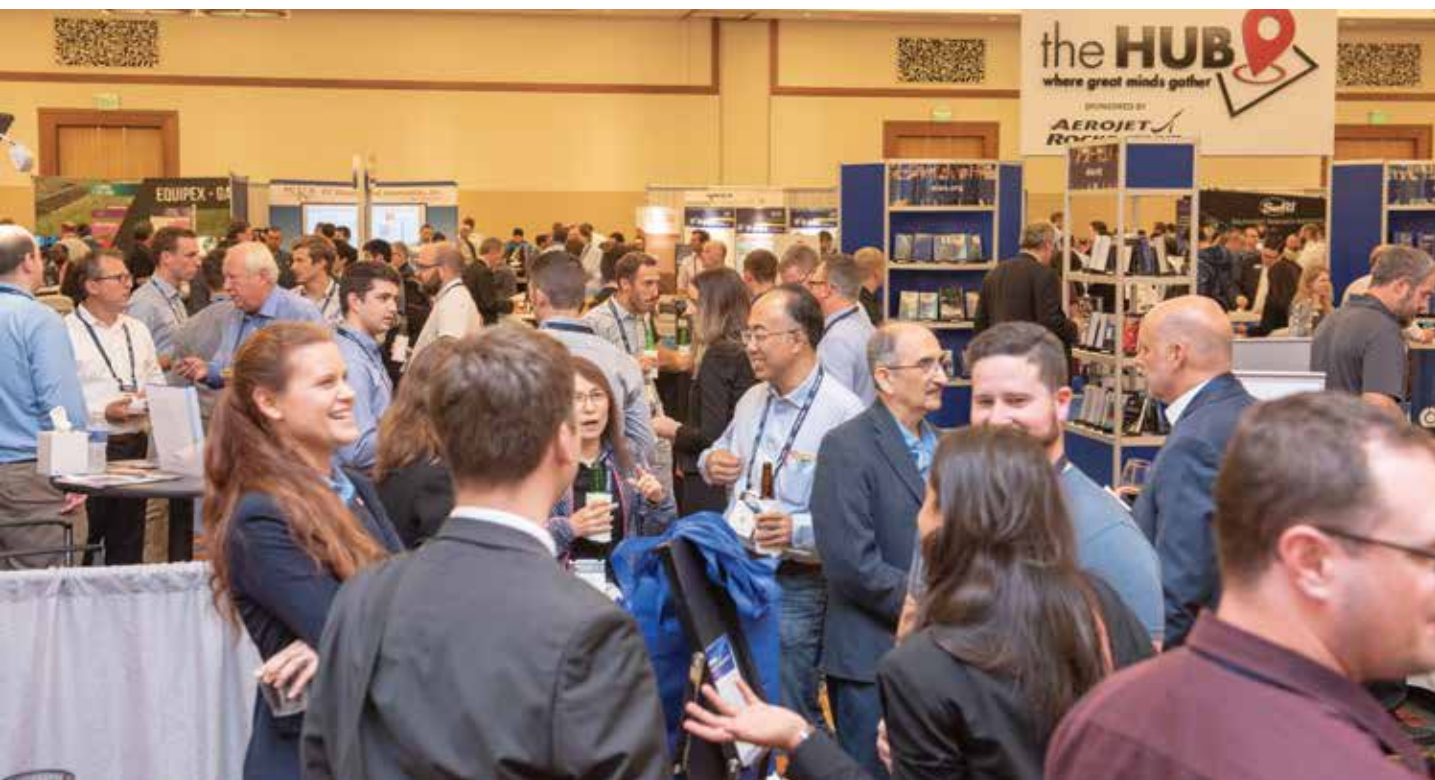
For more information on meetings listed below, visit our website at aiaa.org/events or call 800.639.AIAA or 703.264.7500 (outside U.S.).

6 Jan	Class of 2020 AIAA Associate Fellows Induction Ceremony	Orlando, FL	
6–10 Jan	AIAA SciTech Forum	Orlando, FL	11 Jun 19
14–16 Jan*	2nd IAA Conference on Space Situational Awareness	Washington, DC (icssa2020.com)	
21–23 Jan*	International Powered Lift Conference (IPLC 2020)	San Jose, CA (vtol.org/events/2020-transformative-vertical-flight)	19 Aug 19
25–28 Jan*	Aircraft Noise and Emissions Reduction Symposium (ANERS)	Bordeaux, France (Contact: aerospace-europe2020.eu)	31 July 19
27–30 Jan*	66th Annual Reliability & Maintainability Symposium (RAMS®)	Palm Springs, CA (www.rams.org)	
7–14 Mar*	2020 IEEE Aerospace Conference	Big Sky, MT (aeroconf.org)	
10–12 Mar*	23rd AIAA International Space Planes and Hypersonic Systems and Technologies Conference	Montréal, Québec, Canada	22 Aug 19
18 Mar	AIAA Congressional Visits Day	Washington, DC	
23–25 Mar*	55th 3AF Conference on Applied Aerodynamics — “Turbulent Flows in Aerodynamic Applications”	Poitiers, France (http://3af-aerodynamics2020.com)	18 Nov 19
5–7 May	AIAA DEFENSE Forum	Laurel, MD	8 Oct 19
19 May	2020 AIAA Fellows Dinner	Crystal City, VA	
20 May	2020 AIAA Aerospace Spotlight Awards Gala	Washington, DC	
25–27 May*	27th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (elektropribor.spb.ru/en/conferences/142)	
15–19 Jun	AIAA AVIATION Forum	Reno, NV	7 Nov 19
23–26 Jun*	ICNPAA 2020: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
15–22 Aug*	43rd Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events (COSPAR 2020)	Sydney, Australia	14 Feb 20
24–26 Aug	AIAA Propulsion and Energy Forum	New Orleans, LA	11 Feb 20
14–18 Sep*	32nd Congress of the International Council of the Aeronautical Sciences	Shanghai, China (icas.org)	15 Jul 19
26–27 Sep*	CEAS-ASC Workshop 2019 on “Advanced Materials for Aeroacoustics”	Rome, Italy	
12–16 Oct*	71st International Astronautical Congress	Dubai, UAE (mbrsc.ae/iaac2020)	
29 Oct–1 Nov*	37th International Communications Satellite Systems Conference (ICSSC 2019)	Okinawa, Japan (kaconf.org)	15 May 19
16–18 Nov	ASCEND	Las Vegas, NV (ascend.events)	

PROPULSION ENERGY FORUM

More than 1,600 attendees, including 370 students, representing a broad range of the propulsion and energy community from across the United States and 35 other countries convened in Indianapolis, 19-22 August, for a successful AIAA Propulsion and Energy Forum.





Recognizing Top Achievements An AIAA Tradition

AIAA is committed to ensuring that aerospace professionals are recognized and celebrated for their achievements, innovations, and discoveries that make the world safer, more connected, more accessible, and more prosperous. From the major missions that reimagine how our nation utilizes air and space to the inventive new applications that enhance everyday living, aerospace professionals leverage their knowledge for the benefit of society. AIAA continues to celebrate that pioneering spirit showcasing the very best in the aerospace industry.

AIAA acknowledges the following individuals who were recognized between July and October 2019.

Presented at the 48th International Conference on Environmental Sciences, 8–12 July 2019, Albuquerque, New Mexico

2019 AIAA Jefferies Aerospace Medicine and Life Sciences Research Award



John B. Charles, Ph.D.
NASA Johnson Space Center (retired)
For excellence in biomedical research, scientific leadership, and international cooperation, leading to significant contributions to our understanding of the challenges of long duration human spaceflight.

Presented at the AIAA Propulsion and Energy Forum, 19–22 August 2019, Indianapolis, Indiana

2019 AIAA von Kármán Lecture in Astronautics



Tory Bruno
United Launch Alliance
Vision for a Self-Sustaining CisLunar Economy

2019 AIAA Sustained Service Award



Marty K. Bradley
Boeing Commercial Airplanes
For sustained, significant service at the national level with emphasis on Technical and Program/Integration Committee leadership, including formation of new committees.

2019 AIAA Sustained Service Award



Timothy Dominick
Northrop Grumman Innovation Systems
For sustained AIAA leadership at the section, region, and national committee levels attested by service to the Delaware Section and Public Policy Committee.

2019 AIAA Engineer of the Year



Timothy Dominick
Northrop Grumman Innovation Systems
For successful development and implementation of a novel structural insulator material, JT-700, into multiple controllable solids propulsion systems with potential applications across the aerospace industry.

2019 AIAA Aerospace Power Systems Award



Judith A. Jeevarajan
NASA Johnson Space Center
In recognition of significant contributions to the design, development, and test of safe and reliable battery energy storage power systems for aerospace applications.

2019 AIAA Air Breathing Propulsion Award



Karen A. Thole
Pennsylvania State University
For significant technical contributions to the understanding of convective heat transfer in gas turbine engines, and continuing efforts to promote participation of underrepresented groups in aerospace.

2019 AIAA Energy Systems Award



Arun Majumdar
Stanford University
For superior contributions to the science and engineering of nanoscale energy-conversion materials and devices and outstanding energy-related service at the highest administrative levels.

2019 AIAA Wyld Propulsion Award



Stanley K. Borowski
NASA Glenn Research Center (retired)
For sustained outstanding contributions in advanced propulsion, including the development and application of nuclear thermal propulsion for future human lunar and Mars exploration missions.

Thank you to all the nominators and supporters of these award winners.

2019 AIAA Space Automation and Robotics Award



Orbital Express Team DARPA

In recognition of Orbital Express's pioneering work in demonstrating autonomous orbital robotics, including these firsts: autonomous robotic grapple, robotic ORU changeout, and robotic fluid transfer in space.

2019 Space Systems Award



Jess M. Sponable DARPA

For unique and extraordinary leadership in providing the pathway for the evolution of the United States military launch capability toward robust and affordable reusable space systems.

Presented at the 38th Digital Avionics Systems Conference (DASC), 8–12 September 2019, San Diego, California

Advanced Collision Avoidance System X (ACAS X) Design Team

(L to R) Neal Suchy, FAA TCAS Program Manager; Wes Olson, Assistant Group Leader, MIT Lincoln Laboratory; James Kuchar, Group Leader, MIT Lincoln Laboratory; and Mykel Kochenderfer, Assistant Professor, Stanford University. Not pictured: Joshua Silberman, ACAS Project Manager, Johns Hopkins University Applied Physics Laboratory



For the development of the Advanced Collision Avoidance System X (ACAS X) using machine learning technology, statistical risk assessment, and flight test campaigns.

Presented at the 70th International Astronautical Congress, 21–25 October 2019, Washington, D.C.

David W. Thompson Lecture in Space Commerce



Eddy W. Hartenstein

Broadcom; TiVo; Sirius XM Radio; Tribune Publishing; SanDisk; Technicolor; Converse Communications Satellites

— Then, Now, and Where Next?

Presented at the 37th International Communications Satellite Systems Conference (ICSSC), 29–31 October 2019, Okinawa Japan

Aerospace Communications Award



Michel E. Bousquet

Institut Supérieur de l'Aéronautique et de l'Espace (ISAE)

For his outstanding contribution and promotion of education and proliferation of knowledge on aerospace communication and navigation.

NOMINATE AN AIAA MEMBER!

Now accepting nominations for the Engineer of the Year Award

The Engineer of the Year Award is presented to an AIAA member who, as a practicing engineer, recently made a contribution in the application of scientific and mathematical principles leading toward a significant technical accomplishment.

This award carries a \$500 honorarium and will be presented at the AIAA Aerospace Spotlight Awards Gala.

Submit the nomination package to awards@aiaa.org by 1 November.

For more information:
aiaa.org/AwardsNominations



AIAA
SHAPING THE FUTURE OF AEROSPACE

MAKING AN IMPACT

Supporting the Next Generation's Academic Careers

AIAA is pleased to announce the 2019 recipients of AIAA undergraduate scholarships and graduate awards. The Institute has awarded more than 750 aerospace scholarships to undergraduate and graduate students during the past 20 years.

Applications for the 2020 scholarships are being accepted from 1 October to 31 January (aiaa.org/home/get-involved/students-educators/scholarships-graduate-awards).

"AIAA is grateful to its members who support the academic careers of the next generation of aerospace engineers," said Merrie Scott, AIAA Foundation director. "Your contributions and partnerships with the Institute helps aerospace continue its tradition of pushing the boundaries of what's possible for so many of our student members. You are truly making a difference one student at a time."

For more information and if you are considering endowing a scholarship, please contact Merrie Scott at 703.264.7530 or merries@aiaa.org

Undergraduate Scholarships and Graduate Awards for the 2019–2020 Academic Year



The **AIAA Rocky Mountain Section** presented a \$500 scholarship to **Andrew Meikle**, University of Colorado Boulder, Boulder, Colorado.



The \$10,000 **Daedalus 88 Scholarship**, endowed by current AIAA President John Langford, CEO and President, Aurora Flight Sciences, was presented to **Ara Mahseredjian**, University of Southern California, Los Angeles, California.



The \$10,000 **David and Catherine Thompson Space Technology Scholarship**, named for and endowed by former AIAA President David Thompson, retired chairman, chief executive officer, and president of Orbital ATK, Dulles, Virginia, and his wife Catherine, was presented to **Savannah Cofer**, Rice University, Houston, Texas.

The Digital Avionics Technical Committee presented four scholarships of \$2,000 each:



The **Dr. Amy R. Pritchett Digital Avionics Scholarship** was presented to **Kaelan Oldani**, University of Michigan, Ann Arbor, Michigan.



The **Cary Spitzer Digital Avionics Scholarship** was presented to **Hannah Lehman**, Texas A&M University, College Station, Texas.



The **Ellis F. Hitt Digital Avionics Scholarship** was presented to **Spencer McDonald**, University of Tennessee, Knoxville, Tennessee.



The **Dr. James Rankin Digital Avionics Scholarship** was presented to **Ryan Kelly**, University of Tennessee, Knoxville, Tennessee.



The Air Breathing Propulsion Technical Committee's \$1,000 **Gordon C. Oates Air Breathing Propulsion Graduate Award** was presented to **Veeraraghava Raju Hasti**, Purdue University, West Lafayette, Indiana.



The Guidance, Navigation, and Control (GNC) Technical Committee's \$2,500 **Guidance, Navigation and Control Graduate Award** was presented to **Young Shen**, University of Colorado Boulder, Boulder, Colorado.



The inaugural recipients of the \$5,000 **Dr. Hassan A. Hassan Graduate Award in Aerospace Engineering** are **Jonathan T. McCready** and **Joshua Glazer**, both from North Carolina State University (NCSU). The award was established to entice top NCSU aerospace engineering seniors, who also are AIAA members, to earn their graduate degree (M.S. or Ph.D.) in aerospace engineering at NCSU.



The **John Leland Atwood Graduate Award** was presented to **Garrett Marshall**, Vanderbilt University, Nashville, Tennessee. Established in 1999,

the \$1,250 award, sponsored by endowments from Rockwell and what is now The Boeing Company and named in memory of John Leland "Lee" Atwood, former chief executive officer of Rockwell, North America, recognizes a student actively engaged in research in the areas covered by the technical committees (TC) of AIAA.



The \$1,250 **Leatrice Gregory Pendray Scholarship** was presented to **Anna Liu**, Purdue University, West Lafayette, Indiana.



The \$2,500 **Liquid Propulsion Technical Committee Scholarship** was presented to **EliseAnne Koskelo**, Pomona College, Claremont, California.



The Modeling and Simulation Technical Committee's \$3,500 **Luis de Florez Graduate Award** was presented to **Regis Thedin**, Pennsylvania State University, University Park, Pennsylvania.



The Propellants and Combustion Technical Committee's \$1,250 **Martin Summerfield Propellants and Combustion Graduate Award** was given to **Adam Weiss**, University of California, San Diego, San Diego, California.



The **Neil Armstrong Graduate Award** was presented to **Mike Lotto**, University of Colorado Boulder, Boulder, Colorado. This \$5,000 award honors the character and achievements of the late astronaut, military pilot and educator, Neil A. Armstrong, the first human to set foot on the moon.



The \$5,000 **Orville and Wilbur Wright Graduate Awards**, given in memory of the Wright brothers' contributions to the evolution of flight, recognize two full-time graduate students. The winners are: **David Morata**, University of California, Irvine, Irvine, California
Derek Nichols, Georgia Institute of Technology, Atlanta, Georgia



The \$1,500 **Space Transportation Technical Committee Scholarship** was presented to **Theo Rulko**, University of Michigan, Ann Arbor, Ann Arbor, Michigan.



The \$5,000 **Vicki and George Mueller Scholarship for Aerospace Engineering**, named for and endowed by the late Lt. Gen. George Mueller, former AIAA president, and his wife Vicki, was presented to **Justin Lidard**, University of Maryland, College Park, College Park, Maryland.



The \$5,000 **Wernher von Braun Scholarship**, named in honor of the German rocketeer and founder of the U.S. space program, was presented to **Matthew Corrado**, Georgia Institute of Technology, Atlanta, Georgia.



FOR MORE INFORMATION,
PLEASE VISIT THE AIAA FOUNDATION AT:
aiaa.org/home/get-involved/students-educators/scholarships-graduate-awards

AIAA Announces Section Award Winners

AIAA has announced its 2018–2019 Section Award winners. The section awards honor particularly notable achievements made by member sections in a range of activities that help fulfill the Institute's mission. The Institute believes that vital, active sections are essential to its success.

Section awards are given annually in five categories based on the size of each section's membership. Each winning section receives a certificate and a cash award. The award period covers 1 June 2018–31 May 2019.

The Outstanding Section Award is presented to sections based upon their overall activities and contributions through the year.

Very Large

- 1st** Hampton Roads, Patrick Shea, Section Chair
- 2nd** Greater Huntsville, Alexander Jehle, Section Chair
- 3rd** Los Angeles–Las Vegas, Robert Friend, Section Chair

Large

- 1st** St. Louis, Thomas Rehmeier, Section Chair
- 2nd** Northern Ohio, Peggy Cornell, Section Chair
- 3rd** Orange County, Chase Schulze, Section Chair

Medium

- 1st** Tucson, Eric Hoffman–Watt, Section Chair
- 2nd** Antelope Valley, Jason Lechniak, Section Chair
- 3rd** Wichita, Vicki Johnson, Section Chair

Small

- 1st** Northwest Florida, Chi Mai, Section Chair



- 2nd (tie)** Sydney, Arnab Dasgupta, Section Chair
- 2nd (tie)** Palm Beach, Randy Parsley, Section Chair
- 2nd (tie)** Savannah, Miguel Amador, Section Chair

Very Small

- 1st** Delaware, David Fox/Breanne Sutton, Section Chairs
- 2nd** Adelaide, Mark Ramsay/Sam Aghdam, Section Chairs
- 3rd** Greater New Orleans, Glen Guzik, Section Chair

The Career and Professional Development Award is presented for section activities that focus on career development, such as time management workshops, career transition workshops, job benefits workshops, and technical versus management career path workshops.

Very Large

- 1st Hampton Roads** – Elizabeth Ward and Hyun Jung Kim, Career and Professional Development Officers
- 2nd Greater Huntsville** – Greg Simpson, Section Vice Chair & Alex Jehle, Section Chair
- 3rd Rocky Mountain** – Merri Sanchez, Section Chair–Elect

Large

- 1st St. Louis** – Robert Dowgwillo, Programs Officer

Medium

- 1st Wichita** – Vicki Johnson, Section Chair



Small

- 1st Northwest Florida** – Ryan Sherrill, Career and Professional Development Officer
- 2nd Savannah** – Ricky Odey, Career and Professional Development Officer
- 3rd Sydney** – Divya Jindal, Career and Professional Development Officer

Very Small

- 1st Adelaide** – Sam Aghdam, Section Chair
- 2nd Delaware** – Timothy McCardell, Career and Professional Development Officer

The Communications Award

recognizes sections that develop and implement an outstanding communications outreach program. Winning criteria include level of complexity, timeliness, and variety of methods of communications, as well as frequency, format, and content of the communications outreach.

Very Large

- 1st Hampton Roads** – John Lin, Newsletter Editor
- 2nd Greater Huntsville** – Alex Byers, Communications Officer
- 3rd Los Angeles–Las Vegas** – Lisa Kaspin, Communications Officer

Large

- 1st Northern Ohio** – Edmond Wong, Communications Officer
- 2nd St. Louis** – Andrea Martinez, Publicity Officer
- 3rd (tie) Cape Canaveral** – Jake Shriver, Communications Officer
- 3rd (tie) San Diego** – Abigail Cruz, Section Secretary



Medium

1st Antelope Valley – Patrick Clark, Section Secretary
2nd Wichita – Vicki Johnson, Section Chair
3rd (tie) – Carolina, John Blanton, Section Chair
3rd (tie) – Tucson, Eric Hoffman-Watt, Section Chair
3rd (tie) – Phoenix, Rick Kale, Section Chair

Small

1st Northwest Florida – Daniel Bradley, Communications Officer
2nd Sydney – Arnab Dasgupta, Section Chair
3rd Long Island – David Paris, Section Chair

Very Small

1st Delaware – Christina Larson, Communications Officer
2nd Adelaide – Steven Pietrobon, Section Secretary
3rd Greater New Orleans – Glen Guzik, Section Chair

The Membership Award is presented to sections that have increased their membership by planning and implementing effective recruitment and retention campaigns.

Very Large

1st Hampton Roads – Marlyn Andino, Membership Officer
2nd Los Angeles–Las Vegas – Chandrashekar Sonwane, Membership Officer
3rd Greater Huntsville – Theresa Jehle, Membership Officer

Large

1st St. Louis – Nic Moffitt, Membership Officer
2nd San Diego – Joel Perez and Kathy Kucharski, Membership Officers
3rd (tie) – Atlanta – Aaron Harcrow, Section Chair
3rd (tie) – Orange County, Robert Welge, Membership Officer

Medium

1st Tucson – Rajka Corder, Membership Officer
2nd Wichita – Dustin Tireman, Membership Officer
3rd Antelope Valley – Chris Coyne, Membership Officer

Small

1st Northwest Florida – Michael Kelton, Membership Officer
2nd Twin Cities – Kristen Gerzina, Section Chair
3rd Sydney – Binod Aryal, Membership Officer

Very Small

1st Delaware – Christina Larson, Membership Officer
2nd Adelaide – Patrick Neumann, Membership Officer
3rd Greater New Orleans – Larry de Quay, Membership Officer

The Public Policy Award is presented for stimulation public awareness of the needs and benefits of aerospace research and development, particularly on the part of government representatives, and for educating section members about the value of public policy activities.

Very Large

1st Greater Huntsville – Chris Crumbly, Public Policy Officer
2nd Los Angeles – Las Vegas – Alan Shinkman, Public Policy Officer

3rd Dayton/Cincinnati – Oliver Leembruggen, Public Policy Officer

Large

1st Northern Ohio – Victor Canacci, Public Policy Officer
2nd Orange County – Kamal Shweyk, Public Policy Officer
3rd Atlanta – Bob Greene, Programs Officer

Medium

1st Tucson – Brad Williams, Public Policy Officer
2nd Antelope Valley – Patrick Clark, Public Policy Officer
3rd Wichita – Vicki Johnson, Section Chair

Small

1st Savannah – Scott Terry, Public Policy Officer
2nd Palm Beach – Kevin Simmons, Public Policy Officer
3rd Twin Cities – Cristin Finnegan, Public Policy Officer

Very Small

1st Delaware – Timothy Dominick, Public Policy Officer
2nd Greater New Orleans – Glen Guzik, Section Chair
3rd Adelaide – Sam Aghdam, Section Chair

The Harry Staubs Precollege Outreach Award is given to sections that develop and implement an outstanding STEM K–12 outreach program that provides quality educational resources for K–12 teachers in the STEM subject areas of science, technology, engineering, and mathematics.

Very Large

1st Hampton Roads – Karen T. Berger and Dr. Amanda Chou, STEM K–12 Outreach Officers
2nd Rocky Mountain – Jim Paradise, STEM K–12 Outreach Officer
3rd Greater Huntsville – Ragini Acharya, STEM K–12 Outreach Officer

Large

1st Orange County – Jann Koepke, STEM K–12 Outreach Officer



2nd St. Louis – Jackie Blumer, STEM K–12 Outreach Officer

3rd Northern Ohio – Jonathan Kratz & Julie Kleinhenz, STEM K–12 Outreach Officers

Medium

1st Tucson – Elishka Jepson and Allie Kunkel, STEM K–12 Outreach Officers

2nd Wichita – Minisa Childers, STEM K–12 Outreach Officer

3rd Antelope Valley – Jason Lechniak, Section Chair

Small

1st Palm Beach – Shawna Christenson, STEM K–12 Outreach Officer, and Kevin Simmons, Public Policy Officer

2nd Northwest Florida – Judith Sherrill, STEM K–12 Outreach Officer

3rd Savannah – Alessandra Carno, STEM K–12 Officer



Very Small

1st Delaware – Elishabet Lato, STEM K–12 Outreach Officer

2nd Wisconsin – Todd Treichel, STEM K–12 Outreach Officer

The Section–Student Branch Partnership Award is to recognize the most effective and innovative collaboration between the Professional Section Members and the Student Branch members.

Very Large

1st Greater Huntsville – Brittani Searcy, University Relations Officer

2nd Los Angeles–Las Vegas – Matt Mundy, STEM K–12 Outreach Officer

3rd Hampton Roads – Manuel Diaz (NIA), Forrest Miller (ODU), & Julie Deutsch (VT), Student Branch Liaisons

Large

1st St. Louis – Charles Svoboda, Education Officer

2nd Northern Ohio – Peggy Cornell, Section Chair

3rd Atlanta – Aaron Harcrow, Section Chair

Medium

1st Wichita – Vicki Johnson, Section Chair

2nd Antelope Valley – Jason Lechniak, Section Chair

3rd Tucson – Eric Hoffman–Watt, Section Chair

Small

1st Northwest Florida – John Fay, Section Vice Chair

2nd Palm Beach – Kevin Simmons, Public Policy Officer and Shawna Christenson, STEM K–12 Outreach Officer

3rd Sydney – Nimesh Shete, Education Officer

Very Small

1st Central Pennsylvania – Puneet Singla, Section Chair

2nd Adelaide – Zoe Rich, Student Branch Liaison

3rd Delaware – Kyle Panariello, Student Branch Liaison

The Young Professional Activity

Award is presented for excellence in planning and executing events that encourage the participation of the Institute's young professional members, and provide opportunities for leadership at the section, regional, or national level.

Very Large

1st Greater Huntsville – Nishanth Goli, Young Professional Officer

2nd Hampton Roads – Vanessa V. Aubuchon and Michelle N. Lynde, Young Professional Officers

3rd Rocky Mountain – Alexandra Dukes, Young Professional Officer





Large

1st St. Louis – Stephen Clark, Young Professional Officer

2nd Northern Ohio – Roger Tokars, Young Professional Officer

3rd San Diego – Lindsey Sweeney, Young Professional Officer

Medium

1st Antelope Valley – Joseph Piotrowski, Young Professional Officer

2nd Wichita – Vicki Johnson, Section Chair

Small

1st Sydney – Divya Jindal, Young Professional Officer

2nd Northwest Florida – Ryan Sherrill, Young Professional Officer

3rd Savannah – Barry Haddon, Young Professional Officer

Very Small

1st Delaware – Daniel Nice and Katie Barbour, Young Professional Officers

2nd Adelaide – Shane Farrelly, Young Professional Officer

The Outstanding Activity Award

allows the Institute to acknowledge sections that have held an outstanding activity deserving of additional recognition.

Very Large – Los Angeles–Las Vegas, “Sci-Tech vs Sci-Fi,” Robert Friend, Section Chair

Large – St. Louis, “Meet Aurora Flight Sciences,” Thomas Rehmeier, Section Chair

Medium – Wichita, “An Evening of Eagles – a View from Up High,” Vicki Johnson, Section Chair

Small – Niagara Frontier, “New Horizons Flyby of Ultima Thule,” Walter Gordon, Section Chair

Very Small – Delaware Section, “Race to Escape,” David Fox and Breanne Sutton, Section Chairs



News

AIAA NOS 2019 Honors and Awards Picnic

Bill Marshall, Honors & Awards Chair

On 8 August, the AIAA Northern Ohio Section (NOS) gathered at the Wallace Lake Canopy at Mill Stream Run Reservation, Berea, OH, to recognize award recipients and celebrate the many accomplishments of the past year. Approximately 65 participants had the opportunity to spend some time socializing, renewing acquaintances, playing games, and enjoying a wonderful picnic dinner. Following the meal, honorees of over 30 awards were recognized, including a newly inducted AIAA Fellow, six Associate Fellows, and a Wyld Propulsion Award recipient, among many other technical excellence awards and membership awards.



AIAA NOS Officers (From L to R): Roger Tokars, Ivan Martin, Bill Marshall, Christie Pastor-Barsi, Peggy Cornell, Edmond Wong, Al Juhasz



Section members socializing at the picnic

News



AIAA Delaware Section Helps Sponsor Rocket Rampage!

For the sixth consecutive year, the AIAA Delaware Section, in conjunction with Northrop Grumman, sponsored the Rocket Rampage! summer camp at the YMCA in Elkton, MD. The camp took place the week of 15 July, and the activities centered on celebrating the 50th anniversary of the Apollo 11 moon landing.

Campers learned about the moon, its phases, and lunar and solar eclipses before moving on to a Rockets 101

course, where the campers constructed balloon rockets and straw rockets. Midweek, campers toured the Northrop Grumman Propulsion Systems and Controls facility in Elkton, MD, and rotated through four activity stations: Mentos rockets, cork bonding, soda spinners, and marshmallow landers. Day 4 was Mission Day, where campers participated in simulated astronaut training and made posters to encourage

lunar tourism in the year 2120.

The week culminated in Rocket Launch Day, where campers had the opportunity to launch the Estes model rockets they had built during the week. Overall, the rockets performed nearly flawlessly, avoiding the nearby rocket-eating trees and launching 200 to 300 feet, and attracting the attention of many of the participants from the other YMCA camps and preschool classes.



On 5 September, AIAA President John Langford met with Daedalus 88 Scholarship winner Ara Mahseredjian of the University of Southern California at Aurora Flight Sciences to discuss the many ways that AIAA young professionals can stay engaged after graduation.

Do you want to make a difference?

By making a contribution to the AIAA Foundation, you are shaping the next generation of aerospace professionals.

To date, your contributions have:

- › Funded more than **1,300 K-12 classroom grants**, impacting more than **132,000 students**.
- › Awarded more than **1,300 aerospace scholarships** to undergraduate and graduate students.
- › Supported more than **400 student conferences** engaging more than **13,000 students** providing unique opportunities to apply engineering skills.
- › Sponsored design competitions that have engaged more than **11,000 college students** providing unique opportunities to apply engineering skills outside of the classroom.
- › Enabled more than **140,000 student members** and **9,000 Educator Associates** to continue learning about aerospace science and technology.



For more information and to make a tax-deductible contribution, please visit



aiaa.org/foundation

AIAA will match gifts to the Foundation, up to \$4 million for unrestricted gifts only.





AIAA Utah Section Holds 3rd Annual August is for Aerospace

The AIAA Utah Section and INCOSE cosponsored an August is for Aerospace event on 8 August, in Layton, UT. In addition to local aerospace and systems engineers, VIPs from Northern Utah businesses, universities, and government organizations were invited for a stimulating night of informal networking and formal discussions.

The invitees offered perspectives on the topic of the evening: "Fishing for Talent," which gave the crowd an overview on who everyone was. There was a discussion about the talent pool of aerospace professionals within Utah, how changing employers is healthy for the overall community, and partici-

pation in the overall engineering community and professional societies vs individual companies. One elected representative also encouraged those in the room to run for political office at a time when technology is a big topic at the state legislature. Local universities representatives were interested in feedback so that they are preparing their students for what is needed. They also emphasized that there are advanced degree and certificate programs that cater to full-time professionals.

The evening concluded with networking among the participants, based on topics and positions from the more formal discussions. It was a stimulating evening with a great turnout.

AIAA Section Supports Connecticut ACE Camp

With the support of the AIAA Connecticut Section, the Connecticut Aviation Career Education (ACE) Camp just completed a successful seventh season at the Groton/New London Airport. It was a fun learning experience for the 6th-9th graders as they toured the ATC tower at Hartford/Brainard, Survival Systems and 1109th AVGRAD helicopter repair at Groton/New London Airport, Stellar Avionics at Chester Airport, and aerospace component manufacturing facilities around the state. Students built and tested free flight balsa models, and United and American Airline pilots and professional drone pilots visited the camp.

This year was the largest camp ever, and program director and long-time AIAA Educator Associate Stuart Sharack noted that providing an exemplary educational program for students depends on the generosity of the aerospace community.



AIAA Region I YPSE Conference To Be Held in November

The AIAA Mid-Atlantic Section is organizing the AIAA Region I Young Professionals, Students, and Educator (YPSE) Conference, to be held Friday, 15 November 2019, at the Kossiakoff Center at the Johns Hopkins University Applied Physics Laboratory in Laurel, MD. Young professionals (under age 35), graduate, undergraduate, and high school students, as well as educators, are welcome to submit 15-minute technical presentations on aerospace-related topics. The event will feature networking events including a happy hour, awards presentation, and a keynote address from former NASA astronaut and test pilot Pierre Thuot. Abstracts are due by 15 October and registration for conference attendees closes on 1 November. Please email aiaa.midatlantic@gmail.com or visit ypse19.eventbrite.com for more details.

Obituaries

AIAA Associate Fellow Smith Died in March

Alexander E. Smith died on 1 March 2019 at age 59.

Born in Glasgow, Scotland, Smith attended Glasgow Caledonian University to obtain his undergraduate degree in Electrical Engineering followed by a master's degree in Aerospace Systems at Cranfield University. He began working for the National Air Traffic Service (NATS), the Engineering division of the Civil Aviation Authority (UK). He quickly excelled in his duties and was chosen to represent the UK's interests at the International Civil Aviation Organization (ICAO), a role where he became known worldwide to a great many people.

During his time at NATS Smith attended Westminster Business School (London) and gained his MBA in Finance. He moved to the United States

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

CALL FOR NOMINATIONS

Nominations are currently being accepted for the 2020 **AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award**. The recipient will receive a certificate and a \$7,500 honorarium.

This award honors individuals who have made significant improvements in the relationships between airports and/or heliports and the surrounding environment, specifically by creating best-in-class practices that can be replicated elsewhere. Such enhancements might be in airport land use, airport noise reduction, protection of environmental critical resources, architecture, landscaping, or other design considerations to improve the compatibility of airports and their communities.

For nomination forms, please visit aiaa.org/SpeasAward. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2020.

DEADLINE: 1 November 2019

CONTACT: AIAA Honors and Awards Program at awards@aiaa.org



This award is jointly sponsored by AIAA, AAAE, and ACC.

aiaa.org/SpeasAward



in 1988 to work on behalf of the FAA. After working at MSI and Booz Allen Hamilton, he formed his own company (Rannoch) where he mentored many and launched careers. For 17 years he led the company as its CEO until its sale to SRA in 2008. By this point the company grew to attain a staff of almost 400 people spread across the globe.

Pursuing several lifelong interests in art, music and travelling, Smith also obtained his Ph.D. from the International School of Management based in Paris. His aviation career continued unabated and he expanded his involvement with various institutions, including as part of the AIAA Digital Avionics Technical Committee. He was a Fellow of the Institute of Engineering and Technology, the Royal Institute of Navigation, the Royal Aeronautical Society, and the Institute of Directors. He was also a Chartered Engineer (UK) and a Certified European Engineer (EUR Ing.). He authored over 50 issued U.S. and European patents.

AIAA Fellow Parker Died in April

Norman F. Parker died on 20 April 2019.

Parker started at Carnegie Institute of Technology in Pittsburgh, PA, on a Westinghouse scholarship. World War II interrupted his studies and he served on the Manhattan Project in Oak Ridge, TN. In 1948, Parker graduated from Carnegie Tech, with a Doctorate of Science degree in Electrical Engineering.

From 1948 to 1967, Parker was at North American Aviation, Inc., where he advanced from system engineer to leading the Autonetics Division, best known for its provision to the military of the guidance and control system for the Minute Man missile as well as the inertial guidance system for nuclear submarines. From 1967 to 1968, Parker served as executive vice president and director at The Bendix Corporation in Detroit before joining Varian Associates in Palo Alto, CA, as president, CEO, and director.

Recognized for his superior technical, management, and executive skills, Parker served as director on several

corporate boards, was a member of Sigma Xi (the Scientific Research Honor Society), the National Academy of Engineering, and was a fellow of IEEE and AIAA.

AIAA Associate Fellow Hitt Died in May

Dr. Darren L. Hitt died on 10 May 2019. He was 53 years old.

Dr. Hitt earned his Ph.D. in Mechanical Engineering at Johns Hopkins University in the area of Micro-Fluid Mechanics. After a brief appointment as research fellow and adjunct faculty member in the Department of Physics at Loyola College, he joined the University of Vermont in 1998. He was promoted to Professor in the Department of Mechanical Engineering in 2012, and he embodied the teacher-scholar model of the university.

Dr. Hitt received a prestigious NSF CAREER Award in 2001 for his research on microfluidics. His scientific interests later focused on micropropulsion for nano-satellites, for which he won multiple NASA and DoD EPSCoR awards. His work has translated in technological innovations with several patents and a local company, Benchmark Space Systems, founded by a former Ph.D. student, Dr. Ryan McDevitt.

After his appointment as the director of the Vermont Space Grant Consortium (VSGC) in 2013, Dr. Hitt administered and facilitated a continuous stream of large NASA EPSCoR Research Group awards that contributed to scientific and technological advancements in many areas critical to NASA's mission, including atmospheric entry physics, biofilms, and material sciences. These awards fostered collaborations within academic institutions within the states and with NASA research centers. His office funded multiple innovative research faculty awards, graduate fellowships, and undergraduate internships.

An Associate Fellow of AIAA, Dr. Hitt was a member of the AIAA Fluid

Dynamics Technical Committee from 2008 to 2015. He was also the AIAA University of Vermont Student Branch Faculty Advisor from 2016 to 2019. Among his many other services to the scientific community, he was an associate editor and on the Editorial Board of AEROSPACE. Dedicated to the Department of Mechanical Engineering, he served as interim Department Chair while still an Assistant Professor in 2003 and 2004 and later as Program Head from 2010 until 2012.

AIAA Fellow Felder Died in August

Wilson Felder, a pioneer in the fields of aviation technology and systems engineering, died 20 August 2019. He was 73.

Dr. Felder graduated from the University of Virginia with a B.A. in Geology (1968), M.A. (1972), and Ph.D. (1978). He began his military career by enlisting as a Signaller, and deploying to Vietnam and the Mediterranean Sea aboard the USS Butte (AE-27). He served as an active and reserve Naval Officer, retiring from the active reserve with the rank of Commander (Special Duty, Intelligence).

Dr. Felder was the 15th and second-longest serving director of the William J. Hughes Technical Center, the nation's leading research laboratory for air transportation systems. He also served as the Director of Research for the FAA. Prior to his appointment as a senior executive in the FAA, he was employed by TRW, Inc, where he retired in 2001 after 23 years as Vice President, Aviation Services. Since his retirement from the FAA, he was a Distinguished Service Professor at the Stevens Institute of Technology. His research focused on complex systems—their mathematical foundations, design, and verification and validation.



AEROSPACE ENGINEERING AND MECHANICS AEROSPACE SYSTEMS, UNIVERSITY OF MINNESOTA

The Department of Aerospace Engineering and Mechanics seeks to fill one tenure-track faculty position in aerospace systems.

Applications are invited in all areas of aerospace systems, particularly those that complement current research activities in the department. These research activities include but are not limited to control system analysis and design; state estimation; multi-sensor fusion; dynamics; flexible multi-body dynamics; planning and decision-making; and guidance, navigation and control of aircraft, spacecraft and autonomous aerial vehicles. The department has close ties with other departments and on-campus multidisciplinary centers. In addition, the department has access to excellent experimental and computational facilities. Information about the department is available at <https://cse.umn.edu/aem>

Applicants must have an earned doctorate in a related field by the date of appointment. The successful candidate is expected to have the potential to conduct vigorous and significant research programs and the ability to collaborate with researchers with a wide range of viewpoints from around the world. This candidate will participate in all aspects of the Department's mission, including (I) teaching undergraduate and graduate courses to a diverse group of students in aerospace engineering and mechanics; (II) participating in service activities for the department, university, broader scientific community, and society; and (III) supervising undergraduate and graduate students and developing an independent, externally-funded, research program.

The intent is to hire at the assistant professor rank. However, exceptional applicants may be considered for higher rank and tenure depending upon experience and qualifications. It is anticipated that the appointment will begin fall 2020.

The AEM department is committed to the goal of achieving a diverse faculty as a way to maximize the impact of its teaching and research mission. The University of Minnesota provides equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. To learn more about equity & diversity at UMN, visit diversity.umn.edu.

To be considered for this position, candidates must apply on-line at: <https://humanresources.umn.edu/jobs> and search for Job ID No. 331545 or visit <https://z.umn.edu/4fu3>

Please attach your: 1) cover letter, 2) detailed resume, 3) names and contact information of three references, and 4) a statement of teaching and research interests as one PDF.

Application Deadline: The initial screening of applications will begin on **October 1, 2019**; applications will be accepted until the position is filled.

The University of Minnesota is an equal opportunity educator and employer.



SAN DIEGO STATE
UNIVERSITY

Aerospace Engineering
College of Engineering

Faculty Position

The Department of Aerospace Engineering invites applications for a tenure-track faculty position at the Assistant Professor rank in all areas of aerospace engineering. The Department offers BS and MS degrees in Aerospace Engineering, and participates in Joint Doctoral programs with the University of

California, San Diego, and the University of California, Irvine. The current research programs in the Department include aerodynamics, computational and experimental fluid mechanics, propulsion, aerospace structures, aeroelasticity, guidance and control, and astrodynamics. Applicants for this position will complement and/or expand areas of existing research into emerging areas of research.

Applicants must have an earned PhD in Aerospace Engineering or a closely related field. Applicants should demonstrate potential to establish a high-quality extramurally-funded research program in any area of Aerospace Engineering, including Aerospace Design, excel at teaching and mentoring undergraduate and graduate students, and work collaboratively with colleagues as a team member to advance the program. Recent graduates as well as those with industrial or university experience are welcome to apply.

The College of Engineering is the fastest growing of SDSU's seven Colleges. A newly built state-of-the-art Engineering and Interdisciplinary Sciences Complex has significantly expanded and enhanced facilities in the College with over 95,000 square feet of new space added for research and teaching needs. The city of San Diego enjoys a renowned mild climate year-round and is a family-friendly urban environment. The metropolitan area is the hub of several leading industries, including major defense contractors and aerospace companies offering exceptional opportunities for research partnerships with industry. For additional information about the department and the university, please visit <http://aerospace.sdsu.edu> and <http://www.sdsu.edu>.

SDSU is a large, diverse, urban university and Hispanic-Serving Institution with a commitment to diversity, equity, and inclusive excellence. Women and underrepresented minorities are strongly encouraged to apply. SDSU is a Title IX, equal opportunity employer.

Review of the applications will begin on December 1, 2019, and will continue until the position is filled. Additional information and application procedures are available at: <https://apply.interfolio.com/68116>. Inquiries may be directed to Prof. Satchi Venkataraman, Search Committee Chair, satchi@sdsu.edu.

AEROSPACE ENGINEERING AND MECHANICS AEROSPACE STRUCTURES AND ADVANCED MATERIALS, UNIVERSITY OF MINNESOTA



The Department of Aerospace Engineering and Mechanics (AEM) seeks to fill one tenure-track faculty position in Aerospace Structures and Advanced Materials (ASA).

Researchers engaged in the development and application of modern experimental methods in ASAM are particularly encouraged to apply. Current research in the AEM department includes the development of nanoscale mechanics (molecular dynamics, lattice statics, quasicontinuum method, applied quantum mechanics) and continuum mechanics (phase transformations, phase field models, micromagnetics, stability and bifurcation) for the understanding and discovery of advanced materials and structures. The AEM department has close ties with on-campus multidisciplinary centers, and convenient access to outstanding shared experimental and computational facilities, such as the Minnesota Nano Center, the Characterization Facility, the Center for Magnetic Resonance Research, and the Minnesota Supercomputing Institute. Information about the department is available at <https://cse.umn.edu/aem>

Applicants must have an earned doctorate in a related field by the date of appointment. The successful candidate is expected to have the potential to conduct vigorous and significant research programs and the ability to collaborate with researchers with a wide range of viewpoints from around the world. This candidate will participate in all aspects of the Department's mission, including (I) teaching undergraduate and graduate courses to a diverse group of students in aerospace engineering and mechanics; (II) participating in service activities for the department, university, broader scientific community, and

society; and (III) supervising undergraduate and graduate students and developing an independent, externally-funded, research program.

The intent is to hire at the assistant professor rank. However, exceptional applicants may be considered for higher rank and tenure depending upon experience and qualifications. It is anticipated that the appointment will begin fall 2020.

The AEM department is committed to the goal of achieving a diverse faculty as a way to maximize the impact of its teaching and research mission. The University of Minnesota provides equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. To learn more about equity & diversity at UMN, visit diversity.umn.edu.

To be considered for this position, candidates must apply on-line at: <https://humanresources.umn.edu/jobs> and search for Job ID No. 331546 or visit: <https://z.umn.edu/4fu6>

Please attach your: 1) cover letter, 2) detailed resume, 3) names and contact information of three references, and 4) a statement of teaching and research interests as one PDF.

Application Deadline: The initial screening of applications will begin on **November 1, 2019**; applications will be accepted until the position is filled.

The University of Minnesota is an equal opportunity educator and employer.

Embry-Riddle Aeronautical University Presidential Fellows Cluster Hiring Initiative

Embry-Riddle Aeronautical University has an ambitious agenda for the next five years, focused on expanding its research capabilities, graduate programs, and facilities and recruiting highly-talented faculty. The University strives to expand its presence in aerospace and aviation research and to be recognized globally in select signature research areas while growing its discovery-driven undergraduate programs. In support of this agenda, multiple Presidential Fellow positions will be filled.

Presidential Fellows will hold a Distinguished Faculty position in one of the Colleges across the University's three campuses in Daytona Beach, Prescott, or World Wide. The appointments come with tenure and will be available as early as January 2020.

The University invites nationally renowned candidates in the areas of Aviation Cyber Security, Aviation Data Science and Business Analytics, Flight Research, Unmanned Aerial Systems (UAS) and Autonomous Systems to apply. Candidates for these positions are expected to have an exemplary record of sustained funded research, supervision of doctoral students, an excellent publication record, and experience in building new research programs and leading major labs or centers.

Candidates should have an earned terminal degree in a related field and have the credentials for Associate or Full Professor rank. Women and underrepresented minorities are especially encouraged to apply.

Candidates should specify a preferred home department, college, and campus as well as any desired joint appointment. Candidates must submit: (1) a cover letter; (2) a Curriculum Vitae; (3) a teaching philosophy; (4) a research plan; and (5) the names and contact information of at least three references.

Candidate materials may be submitted online by applying to requisition #190373 at <http://careers.erau.edu>.

Any questions should be directed to the University's Associate Provost for Research, Dr. Remzi Seker at sekerr@erau.edu or 386.226.7409.



FACULTY POSITIONS IN AEROSPACE ENGINEERING OR MECHANICAL ENGINEERING

The College of Engineering at Embry-Riddle Aeronautical University in Prescott, AZ, invites applications for tenure track positions at all levels as early as January 2020.

- **Aerospace Engineering** – All areas, especially Engineering Education, Systems Engineering, CAD, and Autonomous Aerial Systems
- **Mechanical Engineering** – Strong background in robot manipulator kinematics and dynamics and/or mobile robotics.

ERAU places a special emphasis on excellence in teaching and learning, as well as dedication to service and collegiality.

The Prescott Campus of ERAU is a small, residential university in the mountains of northern Arizona where faculty/student interaction is a central theme of the campus environment. Prescott is one of the most livable cities in the Southwest. Located at 5000 ft elevation, it has mild climate, clean air, and nearby pristine wilderness areas and national forests. For more information, visit prescott.erau.edu.
<https://careers.erau.edu/>

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aerospaceamerica.aiaa.org



Assistant/Associate Professor Aerospace Engineering

The AERO Department in the College of Engineering at California Polytechnic State University, San Luis Obispo, is seeking a full-time, academic-year tenure-track faculty position at the Assistant or Associate Professor rank. The projected start date is September 10, 2020. Duties include teaching Aerospace Engineering courses; building a vibrant and innovative research program; and supporting and developing students into engineers ready to thrive in the modern aerospace industry. This position is open to candidates with experience in all areas of aerospace engineering but those candidates in the areas of experimental aerodynamics, spacecraft propulsion, and spacecraft communications are strongly encouraged to apply. Candidates with research or private industry experience are encouraged to apply.

Applicants with an earned Ph.D. in Aerospace Engineering, or a closely-related field. Demonstrated experience and commitment to student-centered learning and teaching, as well as the ability to collaboratively work in multidisciplinary settings is required. Demonstrated proficiency in written and oral use of the English language is required.

Preference will be given to those with experience in working with diverse populations and fostering a collaborative, supportive and inclusive environment. Preference will also be given to those with relevant work experience and those who bring professional capabilities.

Cal Poly's Aerospace Engineering Department offers a B.S. and M.S. in Aerospace Engineering. Cal Poly focuses on undergraduate and graduate education. Our "learn-by-doing" approach involves extensive lab work and projects in support of theoretical knowledge, with extensive interaction and collaboration between students and faculty. U.S. News & World Report ranked the Aerospace Engineering Department top among primarily undergraduate public programs in the nation. For further information about the department, see www.aero.calpoly.edu

Rank and salary are commensurate with qualifications and experience. To apply, please complete the online application at <http://jobs.calpoly.edu/sl/en-us/job/493567?1ApplicationSubSourceID= using Requisition #493567>. Review of applications will begin November 8, 2019 and will continue until the position is filled.

Interested candidates must attach a cover letter, resume/curriculum vitae, transcripts (please note proof of a Ph.D. is required by the start date); statement of goals and plans for teaching and research; qualification summary and teaching preferences; and a diversity and inclusion statement. Please see online posting for instructions where to mail documents that cannot be submitted electronically. Please be prepared to provide three professional references with names and email addresses when completing the online faculty application.

1919 1944

Oct. 7 KLM Royal Dutch Airlines is founded by Albert Plesman and his investors. On May 17, 1920, the airline begins its first commercial service, between Amsterdam and London flying modified de Havilland DH.16s. R.E.G. Davies, **A History of the World's Airlines**, p. 35.

Oct. 13 The Convention Relating to the Regulation of Aerial Navigation is signed in Paris. It affirms the principle of national sovereignty of airspace. It also establishes a commission for the regulation of air commerce. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 11.



Oct. 24 The Curtiss Eagle, the United States' first three-engined aircraft, makes its inaugural public flight, carrying passengers from New York to Washington, D.C. The plane has seats for eight passengers. **Aircraft Year Book, 1920**, p. 257.

Oct. 30 A reversible-pitch propeller, which allows an aircraft to land and stop within 15 meters (50 feet), is demonstrated by the U.S. Army Air Service at McCook Field in Dayton, Ohio. **Aircraft Year Book, 1920**, p. 258.



Oct. 12 The first Boeing B-29, "Joltin' Josie, the Pacific Pioneer," arrives at Saipan, Mariana Islands. It is piloted by Gen. Haywood Hansell, commanding general of the 21st Bomber Command, who has established temporary headquarters in Saipan. The command's first combat mission, on Oct. 28, sends 14 B-29s to attack enemy submarine pens on Truk in the Caroline Islands. K.C. Carter and R. Mueller, **The Army Air Forces in World War II**, pp. 472, 483; F.K. Mason and M. Windrow, **Know Aviation**, p. 49.

Oct. 13 A Hawker Tempest, piloted by R.W. Cole, becomes the first Tempest to shoot down a Messerschmitt Me 262 single-seat jet fighter. **The Aeroplane**, Oct. 20, 1944, p. 410.



Oct. 20 Under Gen. Douglas MacArthur, the U.S. Army and other Allied forces invade the Philippines at Leyte, gateway to the Visayans and the rest of the Philippines. One of the forces' first tasks is to secure the airstrip at Tacloban, which they do four days later. W.F. Craven and J.L. Cate, eds., **The Army Air Forces in World War II**, Vol. 5, pp. 347, 356-360.



Oct. 23 The Battle of Leyte Gulf begins, introducing Japanese Kamikaze ("Divine Wind") suicide plane attacks. Some of these planes sink the USS St. Lo, three escort carriers and other vessels. Among the planes flying in Kamikaze missions is the Mitsubishi A6M Zero-Sen fighter, carrying large bomb loads. Overwhelming American naval airpower combined with the firepower of several old design battleships inflict a decisive defeat on the Imperial Japanese Navy. By the conclusion of the battle on Oct. 25, the Japanese lose three battleships, 10 cruisers and 11 destroyers, eliminating their effectiveness as a fighting force. One of the battleships is the Musashi, the largest battleship in the world. R.J. Overy, **The Air War, 1939-1945**, p. 119.

Oct. 23 BOAC, short for British Overseas Airways Corp., starts the first regular direct air service between Great Britain and Madrid, flying a Douglas Dakota airliner. **The Aeroplane**, Oct. 27, 1944, p. 464.

During October 1944

- Air Commodore Frank Whittle receives the Royal Aeronautical Society's Gold Medal for his work on the development of the jet engine. This is the society's highest honor and has been bestowed on only seven others. **The Aeroplane**, Oct. 13, 1944, p. 406.



- H.J.E. Reid, the engineer in charge of NACA's Langley Memorial Aeronautical Laboratory, becomes the scientific chief of the U.S. War Department's Alsos Mission, which is charged with picking up as much information as possible on the enemy's scientific research and development. M.D. Keller, **Fifty Years of Flight: A Chronology of the Langley Research Center, 1917-1966**, p. 56.

1969



Oct. 1 The Boreas satellite, also called ESRO-1B, that was developed and constructed by ESRO, short for the European Space Research Organization, is launched by a U.S. Scout booster. The

satellite carries eight experiments to study the aurora borealis and related phenomena of the polar ionosphere. This is the third ESRO satellite that NASA has launched. NASA, **Astronautics and Aeronautics**, 1969, p. 323.

Oct. 1 A Lockheed C-5A Galaxy, the world's largest aircraft, takes off from Edwards Air Force Base, California, with a load of 185,976 kilograms, the heaviest ever carried by an aircraft. **Philadelphia Inquirer**, Oct. 2, 1969, p. 3.

Oct. 1 The Anglo-French Concorde 001 supersonic airliner, flown by Sud-Aviation chief test pilot André Turcat, passes the sound barrier for the first time when it flies Mach 1.05 (1,115 kph) for about nine minutes. **New York Times**, Oct. 1, 1969, p. 1.



Oct. 3 Astronaut Leroy Gordon Cooper Jr., who piloted the longest and last Mercury spaceflight, Mercury-Atlas 9 in 1963, and served as the command pilot of Gemini 5 in 1965, is appointed the assistant for the Space Shuttle program at the Flight Crew Operations

Directorate at NASA's Marshall Space Flight Center. In this position, he is responsible for the flight crew training program and also manages astronaut input into the design and engineering part of the hardware development and testing for the space shuttle. However, in June 1970, he retires from NASA to become president of National Exhibits Inc. NASA, **Astronautics and Aeronautics**, 1969, p. 326 and NASA, **Astronautics and Aeronautics**, 1970, p. 211.

Oct. 6 The Soviet Union launches its Meteor 2 weather satellite that is designed to trace cloud cover and detect the presence of snow on dark and daylight sides of Earth and record radiated and reflected heat from the atmosphere. **Aviation Week**, Oct. 10, 1969, p. 191.



Oct. 7 The Space Power Facility that includes the world's largest high-vacuum chamber opens at NASA's Research Center in Sandusky, Ohio. The chamber is 30 meters in diameter and 36.6 meters tall. The Space Power Facility is to test large space electric power generating systems and spacecraft but will first be used for the continued development of the Centaur upper stage rocket. NASA, **Aeronautics and Astronautics**, 1969, pp. 329-330.

Oct. 8 France tests the first stage of its Diamant-B carrier rocket at Vernon, France. The Diamant-B is an improved version of the Diamant A with a more powerful first stage. The rocket is the first satellite launch vehicle not built in the U.S. or the Soviet Union. **Interavia**, November 1969, p. 1,751.



Oct. 8 The General Dynamics F-111A Aardvark supersonic, medium-range

strategic bomber is delivered to the U.S. Air Force's Strategic Air Command at Carswell Air Force Base, Texas. The aircraft is scheduled to become operational in the first six months of 1970. NASA, **Aeronautics and Astronautics**, 1969, p. 331.

Oct. 11 The Soviet Union launches its Soyuz 6 spacecraft, carrying cosmonauts Georgy Shonin and Valery Kubasov from the Baikonur Cosmodrome in Kazakhstan. Their experiments are to include the testing of welding in space by three methods. On the following day, Soyuz 7 is launched with Anatoly Filipchenko, Vladislav Volkov and Viktor Gorbatko. Then Soyuz 8 is launched Oct. 13, carrying Aleksei Yeliseyev and Vladimir Shatalov and is to test lunar landing hardware in orbit. Thus, there are seven cosmonauts in orbit at the same time. Soyuz 7 is to dock with Soyuz 8 while Soyuz 6 is to film the operation, but the main objective is not achieved due to equipment failures. **New York Times**, Oct. 12-14 and 18, 1969.

1994



Oct. 4 A Soyuz spacecraft is launched from Baikonur in Kazakhstan with one German and two Russian cosmonauts. The craft docks with the orbiting Mir space station two days later and exchanges the crew who then return to Earth. NASA, **Astronautics and Aeronautics**, 1991-1995, p. 574.

Oct. 6 Ford Motor Co. and NASA's Langley Research Center sign an agreement to transfer NASA technology to Ford for the improvement of automotive engineering. It is the first agreement of its type with Detroit. NASA, **Astronautics and Aeronautics**, 1991-1995, p. 575.

Oct. 20 NASA announces that it would continue to study how the Earth's environment was changing and how human beings affected that change during the flight of space shuttle Atlantis scheduled to launch Nov. 3. This is the third flight of the ATLAS project, short for Atmospheric Laboratory for Applications and Science, which is part of NASA's Mission to Planet Earth project. NASA, **Release 94-175**.

MICHAEL SEITZ, 26

Electrical engineer at AeroVironment



Growing up in Wooster, Ohio, Michael Seitz kept a box of parts from appliances and devices he dismantled. Although he never managed to reassemble the pieces into new contraptions, he enjoyed trying to fit them together. Now, Seitz designs and tests avionics circuitry for AeroVironment, the Monrovia, California, company that builds the Raven, Wasp and Puma fixed-wing drones for the U.S. military, and the Hawk 30, a solar-powered unmanned flying wing designed to operate for months at altitudes of 65,000 feet.

Landing a job ► I picked electrical engineering as a major because it seemed to have a broad range of opportunities in different industries, and it was something I had an interest in but hadn't found any good resources to teach myself. While at the University of Southern California, I volunteered in a 3D-printing lab, which gave me some physical exercise of the theory I was learning in class. AeroVironment usually had a booth at the Viterbi Career & Internship Expo, and I thought their displays and pamphlets were some of the coolest ones around. The concept of autonomous aircraft was really exciting to me. After speaking with them every semester for four years, I got a call asking me to interview for an associate electrical engineering position.

From desk to flight tests ► I've been here a little over four years now. I've been able to cover a lot of aspects of this design process, from prototyping and printed circuit board design to testing and productionizing a variety of systems, including flight controls, battery management systems and ground station communication. There have been plenty of other times when I was out in the field assisting in flight tests or in the workshop building test fixtures. There's a good amount of variety in what I get to do. The balance between desk and field work and the fast-paced environment definitely keeps it interesting.

Aviation in 2050 ► Electric power systems and autonomy will play a huge role. This not only allows for a decreased reliance upon fossil fuels, but also a possibility for longer endurance, as we have seen from AeroVironment's previous solar-powered designs, since there is no added weight from a pilot and the aircraft refuels in the air. This opens up a lot of possibilities in the commercial marketplace. The skies will inevitably be more accessible to a much larger portion of the population. The growing feasibility of electric aircraft and the increased autonomy in control systems will make for greater reliability and decrease the potential for human error. While a good understanding of aerodynamic principles and aviation practices will still be important, years of pilot experience will not be necessary in order to get off the ground. Regulation will certainly have to play a larger role in this development in order to ensure the safety of these future systems, but I see the somewhat recent explosion of hobby and commercial drone usage to be an example of what we have to expect going forward. ★

BY DEBRA WERNER | werner.debra@gmail.com

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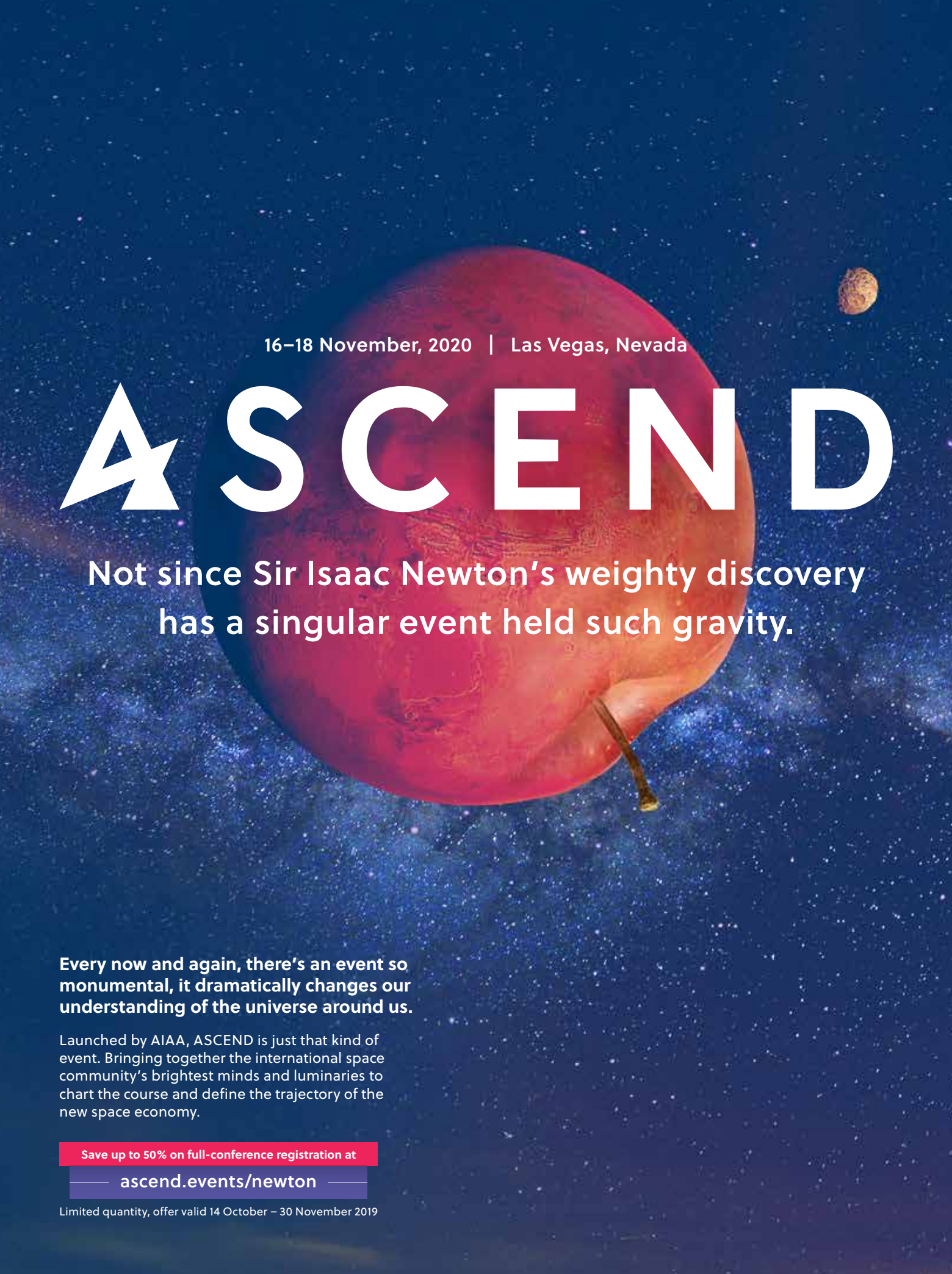
Chris Semon | +1 703.264.7510 | ChrisS@aiaa.org

Vickie Singer | +1 703.264.7509 | VickieS@aiaa.org

Paul doCarmo | +1 703.264.7576 | PaulD@aiaa.org

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