AEROSPACE

★ ★ ★ AMERICA ★ ★ ★

YOUR NEW CYBER ALLIES

Working with, instead of against, gray-hat hackers. PAGE 24

PAGE 14

PANDEMIC COVERAGE
- NASA'S VENTILATOR
- GOING VIRTUAL
- STAYING GREEN

JUNE 2020 | A publication of the American Institute of Aeronautics and Astronautics | aerospaceamerica.aiaa.org

AIAA
SHAPING THE FUTURE OF AEROSPACE

AVIATION FORUM

15–19 JUNE 2020 | **VIRTUAL EVENT**

WHO'S WHO OF AVIATION

The sharpest minds in the industry will participate in the 2020 AIAA AVIATION Forum. The list of confirmed speakers* includes executives, visionaries, and innovators from every sector. Register today to hear from these thought leaders first-hand.

KEYNOTE SPEAKERS

RICHARD ABOULAFIA
Vice President, Analysis,
Teal Group

JAMES BRIDENSTINE
Administrator,
NASA

WALT ODISHO
Vice President, Manufacturing,
Safety and Quality,
Boeing Commercial Airplanes

TOM VICE
Chairman, President, and
Chief Executive Officer,
Aerion Corporation

GRAZIA VITTADINI
Chief Technology Officer,
Airbus

FORUM 360 MODERATORS & PANELISTS

Juan Alonso, Stanford University
Ella Atkins, University of Michigan
Eric Barnes, Northrop Grumman Corporation
P. Barry Butler, Embry-Riddle Aeronautical University
John Cavolowsky, NASA
Peter Coen, NASA
Teri M. Finchamp, Boeing Commercial Airplanes
Ray Gomez III, NASA Johnson Space Center
Irene Gregory, NASA Langley Research Center
Micah Howard, Sandia National Laboratories
Karl Hutter, Click Bond
James A. Kenyon, NASA
Parimal Kopardekar, NASA Ames Research Center
Nick Lappos, Sikorsky, A Lockheed Martin Company
JD McFarlan III, Lockheed Martin Aeronautics
Lee Noble, NASA
Robert Pearce, NASA
Peter Shannon, Radius Capital
Om Sharma, United Technologies Research Center
Richard Wahls, NASA

**Speakers subject to change*

RESERVE YOUR SPOT

aiaa.org/aviation/registration

AIAA
SHAPING THE FUTURE OF AEROSPACE

AEROSPACE AMERICA

JUNE 2020, VOL. 58, NO. 6

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

CONTRIBUTING WRITERS
Keith Button, Robert van der Linden, Jan Tegler, Debra Werner, Frank H. Winter

Basil Hassan **AIAA PRESIDENT**
Daniel L. Dumbacher **PUBLISHER**
Katie Taplett **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

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.

IN THIS ISSUE

Keith Button

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

PAGES 16, 32

Cat Hofacker

Cat joined Aerospace America as staff reporter in 2019 after an internship at USA Today, where she covered the 2018 midterm elections.

PAGES 9, 10

Jan Tegler

Jan covers a variety of subjects, including defense, for publications internationally. He's a frequent contributor to Defense Media Network/Faircount Media Group and is the author of the book "B-47 Stratojet: Boeing's Brilliant Bomber," as well as a general aviation pilot.

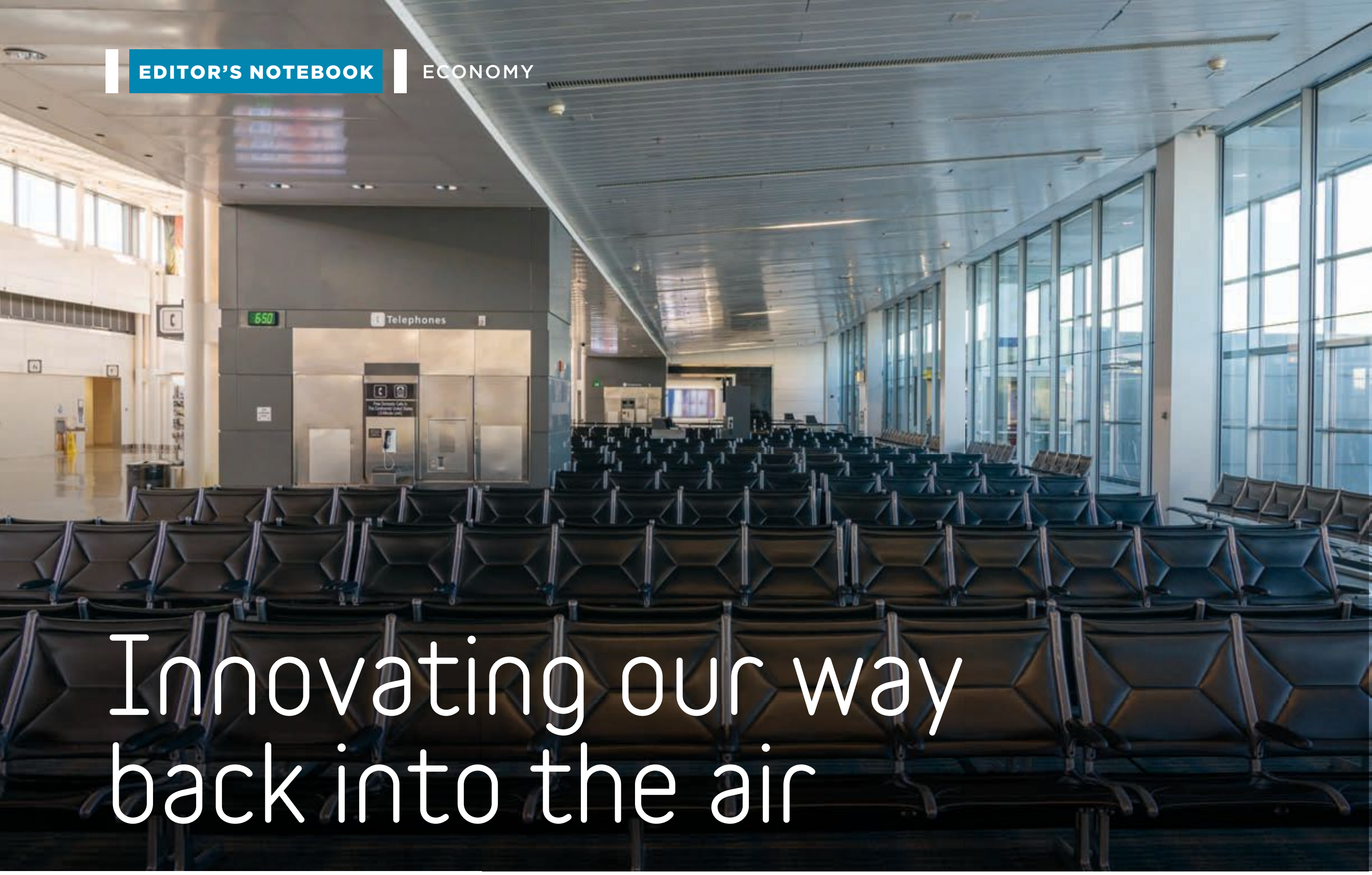
PAGE 42

Debra Werner

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

PAGES 24, 64

DEPARTMENTS



Innovating our way back into the air

I see lots of reasons to be confident that the air transportation industry can rise from this pandemic in part on the strength of business and technical innovations.

There's too strong a research and development community around the world for this not to be true. Look, for instance, at the creativity and moxie of the NASA engineers who devised a prototype ventilator in 35 days for rapid, low-cost manufacturing. That's the kind of achievement that can be made when innovation is embraced and unleashed.

Based on where we are now in the pandemic, it must be tempting for executives to look at TV clips of people shoulder to shoulder at bars in some U.S. cities and wonder if maybe customers won't in fact mind returning to packed aircraft and soon. Maybe surviving is just a matter of hunkering down with some government aid and dwindling rainy day funds.

These TV clips are deceiving, because they are anecdotes rather than data. Polls show that most consumers remain wary of the threat posed by the virus and will be for some time.

Forty percent of air travelers surveyed in April by the International Air Transport Association said they plan to wait "six months or more" after the pandemic subsides before traveling by air.

No one can say for sure when that six-month confidence-building period will begin or what respondents meant by "or more." We've all heard the warnings from epidemiologists about a second wave and many of us have Googled the history of the Spanish flu that started in 1918.

The survivors in the transport industry will be those who adapt rather than simply attempt to wait out the pandemic. They will achieve a critical mass of confident travelers sooner.

I don't know what the innovations will be, but they will make all the difference. ★

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


COVER STORY

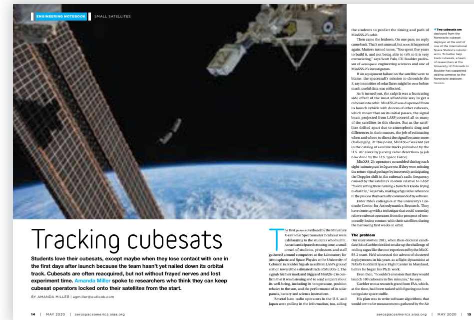
PROTECTING THE OFF-PLANET ECONOMY

Debris tends to stick around in space, and this fact poses a unique challenge for military strategists who are used to keeping the peace elsewhere partly by threatening destruction. This reality complicates the U.S. military's efforts to define how the newly established U.S. Space Force should go about its work and how far that reach should extend as entrepreneurs seek to open up the moon, asteroids and free space to commerce. Debra Werner tells the story.

BY DEBRA WERNER | werner.debra@gmail.com

In the April article "Protecting the off-planet economy," U.S. Space Force Gen. John "Jay" Raymond's title was incorrect. He is chief of space operations.

Also, the article should have said satellite defenses are planned at the National Space Defense Center in Colorado.


ENGINEERING NOTEBOOK | SMALL SATELLITES

Tracking cubesats

Students love their cubesats, except maybe when they lose contact with one in the first days after launch because the team hasn't yet nailed down its orbital track. Cubesats are often reacquired, but not without frayed nerves and lost experiment time. Amanda Miller spoke to researchers who think they can keep cubesat operators locked onto their satellites from the start.

In the Engineering Notebook article "Tracking cubesats" in the May issue, John Gaebler should have been identified as a post-doctoral associate. The article also misidentified the agency from which he is seeking a grant. He is seeking funds from DARPA.

Leading the AIAA Family

I want to thank you, the members of the AIAA family, for entrusting me to lead the Institute for the next two years. 2020 has started off as a challenging year for all of us as we each must deal with the COVID-19 pandemic and wonder what our future holds. Over the last few years, we have seen a lot of changes in our world, our profession, and the Institute we all hold so dear. I want to begin by thanking both Immediate Past President John Langford and Past President James Maser for helping to set our current direction.

My use of the word “family” is by intent. For the last 35+ years, AIAA has been a huge part of my life and my professional development. AIAA serves a wide cross section of members within the aerospace profession, providing many products and services in the form of conferences, publications, professional development, recognition, and networking opportunities. Even in these trying times, we must continue to broaden and enhance what we provide so that each of you can find a place within the AIAA family.

I want to also take this opportunity to reiterate my goals as your president. The first goal is to work with the Board of Trustees, the Council of Directors, and the AIAA staff to create and execute the programs that will increase our membership and engagement with the broader aerospace community. I want us to enhance the value proposition for all our current and potential future members, both individual and corporate. We need to make sure that the member experience is both value-added and timely for all involved. AIAA must be an agile and vibrant organization that can address the changing landscape of our profession.

Secondly, I want to ensure that AIAA’s many products and services remain relevant and avoid becoming stale. In November 2020, we will kick off ASCEND, an event designed to drive the space economy forward by addressing the engineering and business challenges and opportunities we face in the space market today and into the future. While we have had to postpone or cancel several events due to the COVID-19 outbreak, our diligent staff have been working hard to provide virtual content for all our future forums, starting with the fully virtual AIAA AVIATION Forum in June. This added virtual component will enable more members and aerospace professionals to participate in important information exchange, while at the same time providing the critical networking events for those who attend in person. To increase engagement, you will also experience investments in new products and content areas such as autonomy, cybersecurity, and space commercialization, just to name a few.

Finally, and most importantly, when I leave the presidency in May 2022, I want to know that we have invested in our future. I have a goal that every aerospace engineering student (and some from adjacent disciplines) becomes an AIAA student member, and I ultimately hope they transition into professional membership. This future investment will guarantee that our students and young professionals can reap the same benefits as those of us AIAA veterans to help them become future aerospace leaders. My hope is to enhance the student experience via state-of-the-art student conferences and design competitions, and facilitate the transition from student to professional life. For young professionals, I want to provide enhanced virtual offerings like professional development and networking opportunities through our Rising Leaders in Aerospace program and other professional mentoring opportunities. By laying the proper foundation, our students and young professionals will see the value of AIAA and make it a lifelong priority for them in their professional careers. The Board of Trustees, the Council of Directors, and the AIAA staff are all committed to invest the resources in our future, and we look forward to all members taking this journey with us.

The next two years will be a challenge, but we will continue to grow into a stronger and more influential organization. With the governance changeover now complete, we can focus on the future of this great Institute. As we must execute these plans, I ask each of you to provide our leadership with feedback along the way. Thank you again for your commitment and support, and I look forward to the bright future ahead. ★

Basil Hassan
AIAA President (2020–2022)
Email: basilh@aiaa.org

Do you have a puzzler to suggest? Email us at **aeropuzzler@aiaa.org.**

Flapping flyer

Q: You've set your time machine for 1894, Germany, Rhinow Hills. You're standing next to Otto Lilienthal who is about to don his "small wing flapping apparatus." What pocket-sized craft would you bring along, and what would you say to Lilienthal to convince him that his apparatus will not succeed at carrying him for powered flight?

Draft a response of no more than 250 words and email it by midnight Eastern June 7 to aeropuzzler@aiaa.org for a chance to have it published in the July/August issue.

FROM THE MAY ISSUE

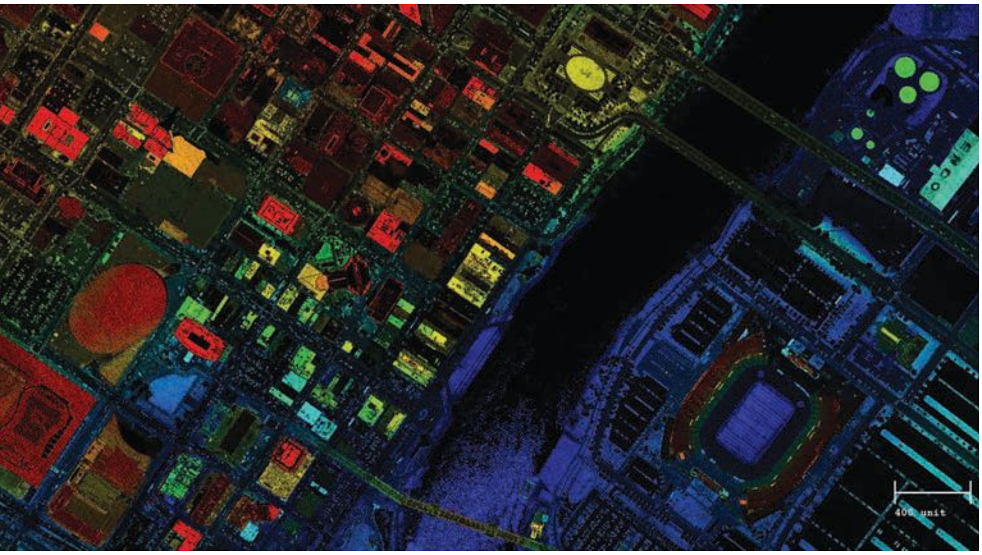
SURVIVING THE FALL: We asked you what maneuver our hypothetical helicopter pilot employed to save the day after losing power. *Your answers were reviewed by helicopter pilot Clint Balog of Embry-Riddle Aeronautical University.*

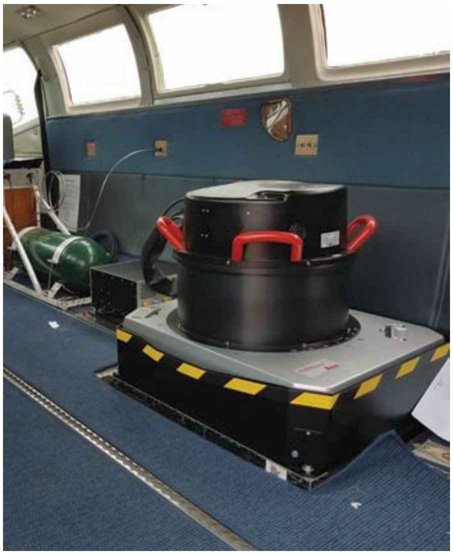
WINNER: The initial loss of power and torque from the engine reduces the lift of the rotor causing an initial acceleration toward the ground making you feel lighter (although not weightless). Even though the angle of incidence of the rotor blades has not changed yet, the reduced rotational velocity has reduced the lift. The pilot chooses a field to land in and starts the autorotation maneuver. He lowers the handle on the collective toward the floor, which reduces the angle of incidence of the blades to a negative value. The relative wind is moving upward against the rotor and the negative angle of incidence keeps the rotor moving the same direction it had been when powered. The rotor accelerates to an appropriate rotational rate as the helicopter nears the ground.

During this constant descent phase, the crew would feel a normal 1-G acceleration. A great deal of rotational (angular) kinetic energy is stored in the rotor at this point. The pilot raises the collective, increasing the angle of attack of the blades and converting angular momentum into lift. This produces enough lift to arrest the rate of descent and allows a soft landing if the timing is right. The positive G forces greater than one from this lift pushing upward is what the crew feels near the ground. The blades start slowing down as soon as the collective is raised so there are only a few seconds of useful lift available to stop the descent before an uncontrolled descent.

Douglas Dobbin
AIAA senior member
El Paso, Texas; douglas.dobbin@gmail.com; Dobbin performs trajectory and risk analyses at White Sands Missile Range, New Mexico, and is a graduate student studying fixed-wing airplane design in the Aerospace Systems Design Laboratory at Georgia Tech.

For a head start ... find the AeroPuzzler online on the first of each month at https://aerospaceamerica.aiaa.org/ and on Twitter @AeroAmMag.





▲ **A lidar map of** downtown Nashville, Tenn., captured in 2016 by a Cessna 404 flown by imaging company Woolpert Inc. Authorities reference such maps to plan infrastructure improvements. Woolpert technicians stripped the interior of the aircraft to make room for the lidar sensor, shown here.
U.S. Geological Survey

Mapping with laser light

BY CAT HOFACKER | catherineh@aiaa.org

Every spring over the United States, aircraft contracted by the U.S. Geological Survey and partner agencies bounce laser light off terrain, buildings and bridges. Computers on the planes record the signal transit times, and back on the ground software turns this lidar data into stunning 3D images.

This is the U.S. Geological Survey's 3D Elevation Program, or 3DEP, in action. Plans call for mapping the entire United States this way by 2023 to produce color-coded elevation maps that organizations at all levels would consult to identify areas at high risk of flooding and inspect buildings, bridges and other infrastructure, among other applications.

Lidar is the technique of choice for these tasks because, unlike aerial photography, "we don't have to worry about the shadows, we don't have to worry about a light source," says Jeff Lovin, senior vice president and marketing director at Woolpert Inc. of Ohio, one of the companies that has been conducting lidar flights since 2015 for USGS and its partners in the federal government and at the state and local levels. The company is under contract to map parts of Wyoming, where officials plan to combine terrain maps with pictures to aid in invasive species detection. The company mapped the entirety of Tennessee between 2015 and 2017 to help state officials avoid a repeat of 2010 and 2011, when it was caught off guard by flooding.

Mapping begins with installing a lidar sensor and computers for data processing onboard an aircraft, a monthslong process that costs almost as much as the plane itself, Lovin says.

"You buy a $300,000 airplane," like a 12-passenger Cessna or Beechcraft, "it's not unimaginable to spend at least $200,000 on getting the plane ready to hold a sensor," he says.

Before technicians can cut a 50-centimeter hole in the aircraft belly to make room for the sensor, FAA must sign off on the plans because "the whole structure of the airframe itself has to be changed to accommodate for that" hole, Lovin says. "You have to go in and brace [the airframe] and make sure the plane is as rigid and safe and operates just as it did originally."

After FAA gives the OK, technicians strip the plane's interior and cut the hole. Most of the barrel-shaped sensor sits inside the aircraft, with only its large lens peering out from underneath the plane like a circular window. Once equipped, the plane receives a final FAA inspection.

Scanning occurs during the early spring when the ground below is clear of snow and leaves. Pilots fly aircraft back and forth in straight lines at about 8,200 feet while the sensor shoots laser pulses through the circular lens, measuring the time it takes reflections to arrive at its receiver. A sensor operator sits in the back of the plane, monitoring incoming data on computer screens.

A four- to five-hour flight generates billions of lidar data points. These value tables, stored on a hard drive, are then mailed to Woolpert's Ohio headquarters, where software combines them with GPS coordinates and other data to create the color-coded 3D maps.

Once the national database is completed, USGS plans to update the terrain maps as needed. ★

Satellite strategist

Of all the possible achievements in 2020, Matt Desch didn't think mastering Microsoft Teams would be one of them. Like most companies, Iridium has largely shifted to telework during the coronavirus pandemic, limiting personnel in the Virginia operations center to those monitoring Iridium's NEXT constellation. The pandemic "demonstrates how essential satellite communications are," Desch says, but even so, some satcom companies won't survive, he predicts. The bankruptcy of aspiring megaconstellation operator OneWeb spells an uncertain future for the remaining broadband ventures. Having emerged from bankruptcy itself in the mid-2000s, Iridium is now carving out its own niche in this increasingly crowded low-Earth orbit. I spoke with Desch from his Virginia home office about these plans. — *Cat Hofacker*

MATT DESCH

POSITIONS: CEO of Iridium Communications since 2006; CEO of telecommunications software provider Telcordia Technologies, 2002-2005; president of global wireless networks at telecommunications equipment manufacturer Nortel Networks, 1996-2000.

NOTABLE: As Iridium CEO, oversaw the deployment of Iridium NEXT and safe disposal of the original constellation. In 2011, Iridium and four air navigation providers created Aireon, a joint venture to track aircraft via Automatic Dependent Surveillance-Broadcast. Under this surveillance method, aircraft broadcast their locations and identities via antenna to receivers on Iridium NEXT satellites, which then beam that information to air traffic controllers on the ground.

AGE: 62

RESIDENCE: McLean, Virginia

EDUCATION: Bachelor of Science in computer science, Ohio State University, 1980; Master of Business Administration, University of Chicago, 1986

More online aerospace america. aiaa.org

IN HIS WORDS

The secret to Iridium's success

If there is a commonality to my strategy over the last 15 years here, it's been "try to do stuff that nobody else can do or wants to do." That will keep us protected from too much investments or too much competition. It will make people attracted to our network because this won't be racing to see who can provide the cheapest service amongst five, six, 10, 20 different companies. That's the reason why we're here. It's the reason why we were able to get through Iridium NEXT and climb that financial mountain. It's the reason why the next 10 years are looking really rosy.

Minimal impact from covid-19

I'd say overall from a business perspective, I'm really glad that if it's going to happen, it happened in 2020. If this would have happened in 2017 or 2018, we would have had a lot higher challenges as we were in the middle of launching our [NEXT] network and climbing the final peak of our financial transformation and everything. With our financing complete, and we're generating cash, and how the network is very solid and working extremely well, we're kind of in a very good place overall. From a customer perspective, certainly we're seeing a little bit of an effect around the edges of different parts of our business. Actually, our sat phone business was doing pretty well with first responders and people trying to get off the grid. We're seeing certainly some effect in some of the aviation business, which is a small part, but traffic is down; airplanes are not flying. We're not on cruise ships; we're more on merchant vessels. They're still sailing, and people still need to call home and connect. Overall, we're not seeing a big impact to our business. We probably won't grow quite as fast as we otherwise would have in the year, but we're going to grow nonetheless, and that's a place where a few companies are right now, particularly if you're in the hospitality or restaurant or travel or any other kind of business. We're weathering it quite well.

The benefits of autonomy

Because of the way we've designed our network and having flown a low-Earth orbit constellation for over 20 years now, anybody who visits us will know that one of our hallmarks is automation. We really automate tons of stuff. You need to do that if you're going to have so many satellites at one time. It's amazing how few people are needed to really be on site and run things. Even now, we've moved our customer care [employees] to their homes and are able to sort of distribute calls from customers and partners straight to them at home. So, people can do that role. But we still have someone, for example, on that team in the office so that they can reference documents or get to something that's necessary. It's all working really smoothly. I think even when [the virus] starts to decline, we're going to be very careful about forcing people to get back together. I think everybody's going to be very careful during that time. That will be interesting to just see how we get started back up — if we really go back to normality quickly, or whether it just takes a little time to do that. We definitely want to keep safe. We want to keep our employees safe. We're just watching it and listening and paying attention like everyone else does.

> "No, you can't do videos. No, you can't have real-time streaming. That's what other companies are good at. That's not what we do. We think that's a unique and valuable market."

"Not shocked" by OneWeb bankruptcy

It's always been hard to develop satellite systems of any type. A lot of people don't appreciate that the big profitable mature companies like Eutelsat and SES and Inmarsat, they are financially mature. For the first 15 to 20 years of their lives as they were building their initial systems and getting started, they were owned by, almost in all cases, by governments. They were private companies who were a public-private partnership with governmental entities, and probably weren't profitable and wouldn't be in business, but they were heavily government subsidized. They all got big enough, and now they can finance their ongoing capital expenses carefully. It's not exciting to some of them, because they're not growing very fast like Iridium is, but they're still financially secure. That's the challenge with all these new startups. These guys are all about where we were in 1995 and 1996 with the launches ahead of us. But you think of the million things we've had to do to create an ecosystem of partners and tons of different products, and a global distribution network of, in our case, over 450 partners who all take us to market and embed us into thousands of solutions. We're quite robust because of just how diverse we are. It took us 30 years to get to that point. We're at 1.3 million and 1.4 million devices on the network, growing at 15-20% a year. That didn't happen overnight. These guys all have to re-create something like that, the equivalent to the broadband world, all in just a few years.

The challenge for megaconstellations

I'm not sure that New Space works all that well for space constellations. When this whole New Space thing came about, the idea of building a lot more lower-resolution imaging satellites instead of a few satellites that cost hundreds of millions of dollars kind of made sense to me because you could start making money taking pictures pretty quickly. Skybox Imaging spent $110 million and got sold to Google for $600 million. [Editor's note: Google purchased Skybox in 2014 for $500 million.] All the venture capitalists at the time thought, "Hey, there's money in the space business. If we could

Before social distancing, Iridium's Satellite Network Operations Center in Virginia.
Iridium

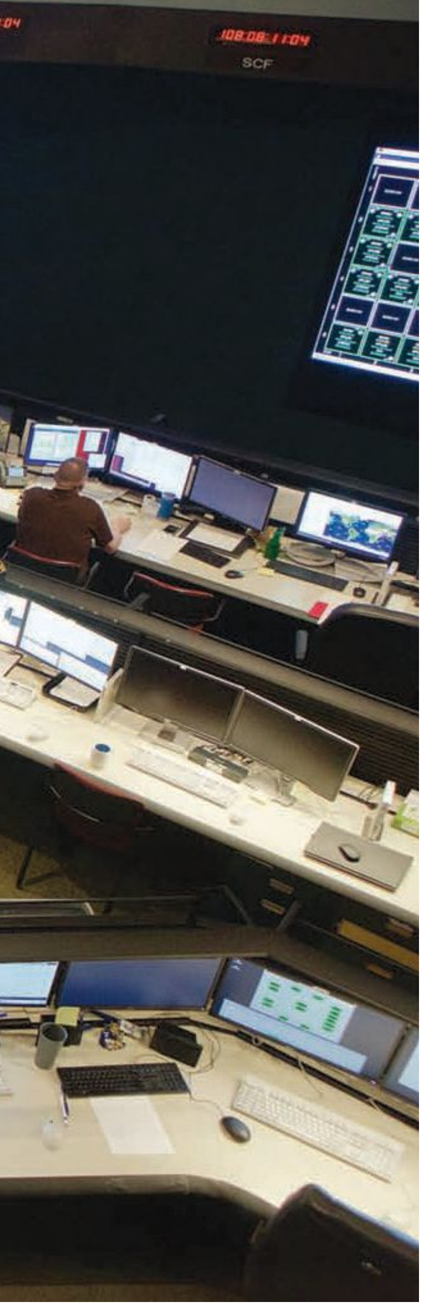
make [satellites] for tens of millions of dollars and take really, really good pictures, we'll just have to build more of them and then they won't last as long." It seemed like that made sense, but they tried to apply that same principle to communications satellites. The problem with building constellations in space is you've got to put maybe hundreds if not thousands of satellites into space before you even can start turning on customers. Otherwise you're telling people, "If you ever launched your Verizon FIOS service, we can use it six to 10 times per day. We can't tell you exactly what it's going to be, but it's going to be really great when you get it." We just wouldn't buy a service like that. These companies are in the same boat right now. That's the challenge. We'll see. Certainly, we have a myriad of challenges that we went through over the last 30 years.

Billionaires beware

That's the challenge with all these new startups, is how do you get to that place in your development career that takes probably 15-20 years with a bunch of impatient investors who are expecting to get returns for all this money that they need to give you to get started? Obviously, what's happening since is that people are going, "Well, billionaires. They're the ones that are going to survive." It is true. Billionaires do have deeper pockets and possibly more patience, but they became billionaires for a reason. Whether it's Elon Musk or whether it's Jeff Bezos or others, they're also going to be very careful about what they spend and how much money of their billions they do spend before they can figure out if this is going to provide the rate of return fast enough for them to do what they really want to do. Unless they're philanthropists, which I don't really recommend long term as the business model; in this business it can be pretty expensive. You can become a millionaire very quickly from a billionaire in that way.

Not a repeat of the big and little LEOs

I think what's happened this time around, there was a lot of enthusiasm starting five or six years ago with Skybox Imaging, and then the investments into all these constellations. As you notice, nobody has gotten the full funding. No one is putting themselves on the stock exchanges. There's not "irrational exuberance," using



the term from the '90s. If anything, people are a lot more careful. I think investors are investing in a lot of small space, but most of the investments are pretty modest still. I don't think you could say that anybody has lost their minds quite yet. OneWeb was probably the furthest along when SoftBank committed the dollars that they did to it. Beyond that, we're still waiting on exactly how much Amazon is putting into it, if at all. It's hard to tell. SpaceX has basically three launches [seven as of May], so they're not being that crazy by testing their ideas carefully. They haven't come out to the public to raise $10 billion or anything to buy into the network. I think people are being a lot more careful this time around. There's history that they're looking back on. I think there is still opportunity, and people are just being careful not to invest as wildly as they did in the '90s.

Iridium's future: internet of things

We're kind of going exactly the opposite direction that everybody else in the industry has done, which has put us in this unique place perfectly suited for this fast growing area where everything wants to be tracked, where information wants to be sent from all kinds of places, devices, application services — whether it's buoys on the ocean or people in a remote place, or oil and gas pipelines, or vehicles of every type and shape. That's where we see the future right now, is to improve and expand on that area. We're only sending little bits of data back and forth, maybe location, temperature, pressure, all kinds of little bits of information. Now with these new devices we're building this year and we'll be building in the future, we can expand the pipe there but keeping very small, low cost, tiny antennas, the thing that you can carry around with you easily in a pocket. You can put it on an animal collar. You could put it in a remote place where the battery would last a long time and still be able to take a picture and send rich data back and forth. No, you can't do videos. No, you can't have real-time streaming. That's what other companies are good at. That's not what we do. We think that's a unique and valuable market. It's really important applications and services that people would want, and there's not anybody doing what we're doing in any kind of significant way. We have sort of a clear runway into the future, which gives us a lot of confidence that we can keep growing and innovating.

Eyes on small sats

We're looking at some partnerships. We're looking at other things. Particularly, I'm more intrigued right now with what I would call the very small sat IoT [internet of things] market. It's kind of complementary to our IoT business. These are companies that are trying to sort of serve the extreme low end of the satellite IoT space. These are things that have really long battery lives, devices that don't need real-time two-way information. They're just basically one way. They just need to send some data and don't care exactly when it is delivered. There's companies that are looking to develop systems that can do that, and maybe only cost $50 million to $100 million of total investment to make that network happen. That's interesting to me. They're not going to need to raise billions of dollars before they get into services. Those are companies that make more sense to me.

No clear solution on space debris

My biggest concern was getting people to understand that there has to be ways of understanding exactly what the reliability of these broadband satellites are going to be and their ability to be controlled. I've been sort of on that more than anything else. As far as we're also seeing that people keep saying, "These are exciting; maybe we can get these debris tugs and bring things down" — I'm all for the development of that sort of technology. Where I'm struggling is who's going to pay for that. Unfortunately, there isn't a solution that's low cost enough that we can put our faith in, will fix the problem after the fact. I put all my energy into encouraging people not to make any more debris. The good thing is gravity will eventually take care of a lot of this over many, many years. But if we can avoid making any more debris, then eventually the problem will go away. If we make it faster than it's getting cleaned up, then we will never be able to fix the problem.

Lining up future launch providers

Certainly, SpaceX would get the first crack. We did select them before they even had a successful launch. We took a big bet to buy seven rockets. It turned out to be eight in the end. We feel like we grew up together and really got to know each other intimately and learned to trust each other and communicate very well. That's a fantastic relationship out in the future. I obviously would hope someday if we have to do this again, that we'll be able to utilize them again. In the end, as an operator, you want to get into the space as safely and as reliably, as inexpensively as you possibly can. That's your goal. As long as they've stayed the leaders in that space, there'd be no reason why we wouldn't want to utilize them. You don't look around and say, "Oh, there's somebody else," for example, Rocket Lab. I think they're doing great, great stuff right now, but their rocket is too small for our satellites. Relativity Space, we've been talking to them and are intrigued with what they're doing. I'm just sort of intrigued personally to see what it's like to 3D-print something that's large. That's their role. I'm sure they'll be not just printing rockets, but planes and airplanes, and other really large structures if they get really good at that. I think that's kind of cool, but we'll keep an eye on the industry. ★

COVID-19 COVERAGE

PANDEMIC

RESPONSE

▲ **The components** of the VITAL Pneumatic brassboard are laid out on a bench connected to the blue and white test lung simulator as engineers test the design's output.

NASA

Inside NASA's ventilator project

Engineers made a host of rapid innovations and faced some surprising challenges to win medical approval for a ventilator prototype in just over a month. They shared their story with Keith Button.

BY KEITH BUTTON | buttonkeith@gmail.com

Early in March, David Van Buren, a flight projects engineer at NASA's Jet Propulsion Laboratory in Pasadena, California, was growing concerned about projections of global ventilator shortages for severely sick covid-19 patients. His idea: Put the lab's engineers to work on designing prototype ventilators that manufacturers could then mass produce quickly for the hospitals that would need them as the number of their coronavirus patients climbed.

The lab's chief engineer, Rob Manning, signed off on the idea and within a few days — on March 16 — Van Buren explained the concept to co-workers at the Left Field design bay, so named for the far-out spacecraft ideas that engineers have shared over the years on the room's white boards. In 35 days, the team of 100 enginners finished building the first of two prototypes, and two days later it was at the Icahn School of Medicine adjacent to Mount Sinai hospital in New York City for testing. The prototype was hand-delivered there via a commercial flight, giving it its own seat.

The U.S. Food and Drug Administration approved the design on April 30 for emergency use. About 100 manufacturers around the world have now asked to license the design at no charge from Caltech, which operates JPL for NASA. As of late May, engineers from the design teams were evaluating and scoring the license applications and meeting virtually with applicants in 30-minute sessions to answer questions.

FDA approval of a second prototype is pending.

As the engineers gathered in March at the Left Field bay, the task brought to mind a certain TV character known for escaping jams with just his wits and duct tape. "As you might imagine, the term 'MacGyver' came up," says Michael Johnson, an electro-mechanical engineer at the lab and chief engineer for the ventilator design team.

▲ **Engineers at NASA's** Jet Propulsion Laboratory in Southern California pack the VITAL Pneumatic prototype ventilator for sending to the Icahn School of Medicine at Mount Sinai in New York, where it was to be tested.

NASA

"We know nothing"

They decided to write up a set of requirements, just as they would when starting an aerospace project. They sought out a pulmonologist at Huntington Hospital in Pasadena to teach them what a ventilator for a covid-19 patient would have to do. The basic idea of a ventilator is simple: It channels compressed air supplied by an outside source or by its own fan turbine into the lungs and then opens a valve to let the lungs push the air out. Before the tutorial, the engineers figured that the task would be akin to figuring out how to rhythmically inflate and deflate a balloon. But then the doctor explained the problems that sick lungs present, such as over-inflation that can occur in a patient over time when the ventilator repeatedly fails to allow the lungs to breathe out fully, a problem called breath stacking. At that point, Johnson says, the engineers looked each other with a new realization: "We know nothing."

From the doctor's tutorial and subsequent consultations with other doctors at Huntington Hospital and Santa Monica College, the engineers set the critical parameters that their ventilators would need to maintain for covid-19 patients. To avoid breath stacking, for example, the engineers designed flow and pressure regulators and sensors to maintain the correct lung pressure and breath intervals as set on the machine by a health care provider. Alarms would be triggered by certain pressure, flow or interval readings.

To keep the designs as simple as possible, they wouldn't try to build ventilators that could handle a range of sicknesses, like most commercial

▲ **The VITAL Pneumatic** prototype designed and built by NASA's Jet Propulsion Laboratory in Southern California.

NASA

ventilators do. "If we can make them simple and low-cost enough, then there could be a whole lot more of them, easier and quicker" to build, Johnson says. Also, their ventilators couldn't have any of the same parts that other ventilators had, or else they would just siphon off the supply chains of others and wouldn't contribute a net addition to the global population of ventilators.

Once they had set up their requirements, the engineers brainstormed and came up with as many initial designs as they could, just as they would with a new aerospace project. Their goal was to carry as many designs as possible to the prototype stage because more viable designs would mean more opportunities to increase the overall supply of ventilators for the pandemic. At this point, the engineers resisted any urge to look at existing ventilators, because they wanted to come up with designs while being completely blind to how anyone else would do it, Johnson says. "That has benefits in that you don't get poisoned in your thinking."

Settling on two prototypes

They started with four designs for their VITAL prototypes, short for Ventilator Intervention Technology Accessible Locally. They quickly narrowed the field to two: the VITAL Pneumatic (the prototype built in 35 days) plugs into the pressurized air lines in hospitals. The other design, called the VITAL Compressor, supplies its own pressurized air for situations when air lines are not available, such as in tent hospitals. VITAL Compressor's prototype was completed in May and a digital file of its design — containing nearly 800 pages of drawings, schematics, instructions for use, photos, data and analysis — was sent to FDA in Washington, D.C., for approval. Other than electronics, the two designs share none of the same parts, so they won't cannibalize each other's supply chain. Sharing electronics seemed reasonable because "making a few hundred thousand of something is low-quantity" for electronics manufacturers, Johnson says.

Once the engineers had settled on their designs for these two prototypes, they looked at how existing ventilators were built and were struck by the number of parts in a typical machine: 3,000 to 4,000, compared to fewer than 100 for either of the VITAL designs. They had succeeded at keeping their designs as simple and cheap as possible.

Next, the engineers had to physically build their designs in the brassboard stage by assembling parts end-to-end in a line on a bench to see if they worked before packaging them in a box for the prototype stage. By the second day of the project, the engineers were buying parts, and by the fifth day they had assembled parts on a bench to operate with an

“If we can make them simple and low-cost enough, then there could be a whole lot more of them, easier and quicker.”

— Michael Johnson, NASA’s Jet Propulsion Laboratory

artificial test lung they had borrowed from Santa Monica College that had used it for respiratory therapy training.

As the engineers added parts to the brassboard, they learned from talking to the parts vendors that some parts wouldn’t be available in large quantities — tens of thousands — for mass production, so they switched them out for parts that would be available in the quantities needed.

The engineers needed to make sure the two ventilators would work well with the doctors and nurses who would be using them. So they sought their advice, inviting doctors into the lab five or six times and holding a daylong web conference with 60 to 80 doctors, nurses and ICU specialists. They tested their first prototype, VITAL Pneumatic, with the Icahn School of Medicine. They also worked with FDA officials starting on the second day of the project to make sure the designs would meet the agency’s requirements. Just before the engineers built the first prototype, they invited a doctor to the lab to see if he could operate the control panel shared by VITAL Pneumatic and VITAL Compressor. When the doctor walked up to the panel and intuitively figured out how to make an adjustment, without any instructions, the engineers cheered. “We were all jumping up and down and yelling ‘Yeah!’” Johnson says.

Turning down the heat

The next step was to install the components into boxes to create the prototypes. At this stage, they encountered a new enemy, especially for the VITAL Compressor: heat. Because the ventilators can be called upon to deliver 100% oxygen to some patients, the engineers had to make sure nothing got hot enough to produce an ignition hazard.

The heat issue with the VITAL Compressor surprised the team, given that its design looked much simpler than the pneumatic design. “We thought: ‘Oh, this is going to be so much easier to put together; it will go quicker; this is going to be better in every way,’” Johnson says. But VITAL Compressor was “a thermal nightmare,” mainly because of heat generated by the motors that compressed the air. Their first attempt at a prototype produced air for breathing that was hair-dryer hot.

Because time was of the essence, the engineers decided to forgo their normal process, which would have been to create a detailed model with a step-by-step analysis to zero in on the most likely factors contributing to the heat problem. Instead, they solved the heat issue by making every thermal design change they could think of, all at the same time: adding fans to vents to move air through the housing, changing the motor mounting so heat was pulled out of it more directly, sealing off the air around the motor from the air that is pumped to the patient, adding a muffler that provided some cooling and modulating the current to a solenoid.

The team also wasn’t too proud to seek advice about how to safely pump medical oxygen. They turned to Jonathan Tylka, an expert on medical equipment testing at NASA’s White Sands Test Facility in New Mexico, about the potential ignition hazards posed by overheating or other factors as the ventilators did their pumping. The engineers were familiar with the hazards of managing oxygen stored at 2,000 to 5,000 pounds per square inch for rocket propulsion, whereas medical oxygen typically flows at 0.5 to 1 psi. “That’s a case where our aerospace experience actually worked against us,” Johnson says. “We had to learn in fact the opposite: At low pressures, it’s not quite as dangerous.”

The team had averted some challenges and met others. The task, overall, was not as simple as they thought, and the next step will be to hear that their handiwork is indeed saving lives. “It’s possible to find a team here who can do just about anything. After all, our team can drop little RC [remotely controlled] cars on Mars and drive around and do geology,” says Van Buren.★

Don't sideline environmental sustainability

An air transport industry in survival mode must continue to innovate toward sustainable aviation fuels, cleaner engines and other technologies. Airline strategist Asteris Apostolidis makes the case.

BY ASTERIS APOSTOLIDIS

The global coronavirus crisis has made many of us re-evaluate various aspects of our lives, and the air transportation industry is beginning to do the equivalent. Much of the personal anxiety related to the pandemic does not derive from the present but mostly from our projections of the future, including fears about job security and the long-term economic effects of the pandemic.

In this environment, it could be tempting for the air transportation sector to think only about short-term survival and back away from an emphasis on environmental sustainability that was just beginning to emerge, though with pushback from some, before the virus struck. Backing away would be a mistake. Sustainability in aviation should not be discarded anymore as a niche topic; rather, it needs to be adopted as a core strategy, and the timing is now more relevant than ever.

The coronavirus crisis provides a shaking warning about how quickly things can go off track for businesses due to a crisis. Four months into the pandemic, the whole air transport sector remains in a virtual standstill. The pandemic is today's crisis, but once it subsides climate change could become the next one, both in terms of environmental impacts and the changing preferences of the traveling public.

The pandemic is triggering strong reactions related to climate change. The link between the two can be attributed to the improved atmospheric quality we see with the reduction of general transport and industrial activity during the pandemic. We are all witnesses to a cleaner planet, transformed in just a few weeks, and this fact shows that an environmental recovery is possible.

With oil prices tumbling since early March to a record-breaking collapse, Jeffrey Currie, head of commodities research at Goldman Sachs, told The Guardian newspaper that the fallout of the pandemic will likely "permanently alter the energy industry" and "shift the debate around climate change."

Indeed, because expectations drive the stock markets, funds related to sustainability performed better than conventional funds during the first quarter of 2020 that ended in March. Morningstar, a

Chicago-based financial services firm, estimates that covid-19 will make the divergence between the two higher, as investors gradually see the fundamental shifts in corporate strategy.

I have read various opinions regarding a prospective recovery of the oil industry, even after a recent OPEC agreement among the world's largest producers to cut supplies. However, there is a common denominator in the views of experts: The days of oil seem to be numbered and the only difference in views centers on how fast societies will embrace alternative fuels and energy generation.

This time frame will not be the same around the globe; it depends on a mix of geopolitics, investments, government emission targets and, of course, consumer behavior. Many of those elements are unpredictable, and some of them can act as a self-fulfilling prophecy.

Before the pandemic, 72% of transportation greenhouse gas emissions in Europe were due to road transport, compared to 14% for air transport, according to the European Environmental Agency. Intense research activity is underway in Europe in all relevant scientific areas, with the objective of a net-zero carbon outcome by 2050, the goal set by individual countries, as well as governmental institutions and agencies.

The degree of progress toward that goal varies depending on the transportation domain and the particular technical impediments. For example, electrification of road transport is advancing at a satisfactory level, with the emissions depending largely on the mix of electricity-generating technologies at the local level. Electrification of air transport in Europe lags behind road transport, however. This lag is partly because of some unique characteristics of commercial aviation. Predominantly, developers of fully electric and hybrid-electric propulsion systems have found it extremely difficult to challenge the combination of energy density of kerosene and power density of gas turbine engines. Therefore, there is no apparent alternative to gas turbine engines for long-haul air travel.

In that perspective, the pandemic might be a challenge to business travel, which can be partially replaced by different forms of teleconferencing. For recreational travel, a global recession might cause some people to refrain from taking long and expensive vacations for a time.

The economic repercussions of the coronavirus, as deep as they are, are likely to subside before radical developments in sustainability are achieved. Rather than wait things out, we should seize the opportunity to fundamentally change some of the chronic weaknesses of our domain and emerge more efficient and environmentally conscious. The vehicle to work toward this goal is to improve our innovation initiatives, despite the surrounding crisis. We need industrywide synergies and partnerships with academia and an open discussion on the mutual benefits these initiatives can bring. After all, resilience and adaptation to the new reality are essential for the survival of any company hit by these inevitable social developments. Immediate survival must, of course, be the most imperative objective of any organization, but equally important is the redefinition of that organization's scope and social mission through turbulent times. There are many examples from different industries where companies failed to adapt to social changes, with catastrophic results.

Transport organizations fundamentally serve the society by bringing people together and supporting the circulation of goods. This is even more important in times of crisis, such as the one we are going through. Airlines support the global circulation of medical supplies and personal protective equipment, while repatriating people stranded in all the corners of the world. This is something embedded in our fundamental scope. However, when the crisis is over, other existential questions will emerge, and the pressing environmental movement will be more relevant than ever. The response of different companies by a redefinition of their mission will affect their appeal to the societies they serve. Tough decisions will need to be made, but it is evident that only the ones that heed the contemporary needs of the general public will be able to make it to the coming years and decades.

Among my peers in the air transport industry, there is lots of discussion about the figurative day after the crisis. Are we going to be the same as an industry? No one can reply precisely to this question, but there are some indications already. Additional coronavirus outbreaks are expected before a vaccine is approved. This will have a permanent impact on the way travelers are allowed to enter foreign countries. For example, body temperature scanners might become a common practice for airports. In addition, movement tracking via smartphones is already a reality, monitoring whether people have recently visited points of outbreak. These kinds of restrictions have the potential to merge with the desire for sustainability and radically transform the way we fly. ★

▲ **This illustration** shows NASA's conceptual STARC-ABL aircraft, short for Single-aisle Turboelectric Aircraft with Aft Boundary-Layer Propulsion. Generators on the wing engines would create electricity to power a fan at the rear of the plane.

NASA

Asteris Apostolidis is a Netherlands-based aviation innovation strategist specializing in sustainable technologies. He has a doctorate in aerospace engineering from Cranfield University and is the innovation strategy manager at Air France-KLM Group. The views expressed in this article are his own and do not necessarily reflect those of Air France-KLM.

The coming digital reality

Technologies that provide us with immersive presence from afar were becoming popular even before the coronavirus pandemic, and they are likely to become even more popular now. NASA's Dennis M. Bushnell sees implications for air travel and space exploration.

BY DENNIS M. BUSHNELL

Real-time human interaction at a distance has evolved over time from the telegraph to the telephone to early video and, in the last few years, to augmented reality, virtual reality and holographic projections, all of which provide degrees of immersive presence. Today, we have early forms of telecommuting, teleworking, teleshopping, tele-education, telemedicine, telepolitics, telemanufacturing, telecommerce and teletravel.

Taken together, we are witnessing early development toward virtual worlds satisfying all five human senses. The tele-everything milieu is headed toward real-time actualization, in which a shopper, for instance, will enter a virtual world and personally choose and order an item.

The coronavirus pandemic is likely to accelerate progress toward this kind of sophisticated immersive presence, with potentially profound impacts for air travel and human space exploration.

Teletravel, in particular, appears to presage a significant reduction in the demand for long-haul air travel with a concomitant impact on the need for aircraft research and development work. Digital reality and immersive presence technologies are increasingly less costly with increasing bandwidth, storage and computing speeds. Also, significant progress has been made over the last two years or so on brain-to-machine communications. With these improvements, the technologies are becoming serious competitors to physical business travel and, increasingly, leisure travel.

For consumers, the benefits of teletravel over physical travel are legion and include:

- Social distancing/working at home during pandemics
- Major cost reductions and time savings
- Less time spent in airline security lines and less hassle
- Being anywhere at any time with multiple contacts/places/meetings on a given day
- Lack of physical and health risks, no overcrowded sites/venues
- Greatly reduced CO_2 emissions and thin cirrus clouds
- The infirm can enjoy the thrill of travel
- Superb educational experiences
- Enable nonverbal/body language communications

The worldwide virtual meeting market was, pre-coronavirus, worth some $4 billion a year. Now, as societies emerge from the pandemic in which virtual meetings proved invaluable, virtual meetings are likely to become commonplace. Teletravel, that is, travel beyond ordinary day-to-day commuting, provides overall greater efficiency, quality of life and balance between work and family life. As we enter the post-coronavirus period, which will be typified by economic issues, organizations will try to rapidly regain lost business. Given the extensive requisite during the coronavirus period of social physical disengagement in favor of virtual interactions, utilization of digital reality and tele-everything will be accelerated with resultant potential impacts on business air travel.

A sizable acceleration of the ongoing shift from physical air travel to digital reality, if it indeed occurs, would affect the economic health of the air transport industry as a whole, from research to construction of the necessary infrastructures and vehicles. However, there would still be a healthy air cargo industry, and perhaps not much additional impact on the nascent development of unmanned air systems, urban air mobility aircraft and personal air vehicles, beyond the ongoing and long-standing shift to telecommuting/telework. These are mostly short stage length with fewer benefits overall than long-haul passenger digital reality.

One worry is that older members of the population could increasingly be left out of modern society. This issue devolves mainly from the millions of years of human evolution involving direct human-to-human contact. Except for the telephone, the dominant form of direct interaction was still direct person-to-person contact even as the enabling digital reality technology was developed over these last decades. Baby boomers grew up on physical interactions, and many decry the shift to virtual technologies. Much of our employment for teachers and professors, the travel industry as a whole (some 10% of global gross domestic product), the physical shopping venues, medical professions and much more rely on physical interactions. However, more recent generations have grown up on increasing use of nonphysical, virtual interactions, which are, by them, increasingly considered the norm.

There is a classic quote in science that fits this generational transition well. It says that new theories emerge one funeral at a time as adherents to old ideas die. There is anecdotal information that, even at the kindergarten level, children are texting their friends across the playground. Teletravel and other forms of digital reality reflect the fact that humans are, in a sense, evolving through the advent of new technology, including artificial intelligence. We appear to be merging, we and the machines, even as digital reality produces what is commonly termed "The death of distance."

One impact of this merging could be to force government and industry to reconsider the proper functions of humans in space, given that the costs of equipping humans for survival out there are many times that of robotic operations. Humans would still go, but not right away. Instead, NASA and private-sector explorers could first send robotic devices that would gather up regolith and rocks and additively manufacture this raw material into the equipment required for in situ resource utilization, or ISRU, by the humans who follow. This step would save the cost and risk of hauling the ISRU equipment there and requiring human explorers to check out its performance on the celestial body. Once the robots have produced and proven out the equipment, then the humans could go at much lower cost and increased safety.

This shift to digital reality in aerospace comes in the context of a large number of technological changes. Solutions are being sought to climate change and our crashing ecosystem. Progress is being made on quantum computing, artificial intelligence, 3D-printed superb microstructure materials, renewable energy, quantum and optical communications and more. Humans are on their way to becoming cyborgs given advances in machine-to-brain communications. Nearly everything is changing, and in the aftermath of the coronavirus those changes that are economically advantageous such as teletravel will probably be accelerated. ★

Dennis M. Bushnell is chief scientist of NASA's Langley Research Center in Virginia and an AIAA honorary fellow.

HACKERS AS ALLIES

The aviation industry once treated all hackers as threats, even those who sought a bit of fame but not necessarily fortune by publicly demonstrating vulnerabilities without causing damage. Debra Werner says the industry's view of these hackers is changing.

BY DEBRA WERNER | werner.debra@gmail.com

Patrick Kiley was in Florida for a cybersecurity training conference in 2017 when he stopped by the Sun ’n Fun Aerospace Expo, the vast annual gathering of aircraft buffs in Lakeland. At home in Las Vegas, Kiley was building a four-seat variant of the Long-EZ, a two-seat kit airplane design from the Rutan Aircraft Factory. He stopped to listen when he met some fellow home-built aircraft aficionados who were talking about linking their various onboard electronics with CAN bus, a standard common among mechanics for wirelessly linking microcontrollers and devices within a vehicle.

As a self-described “car hacker” and principal security consultant for cybersecurity firm Rapid7, Kiley knew that the Controller Area Network bus required no authentication, meaning anyone with physical access could take control of the steering wheel or brakes. He wondered if CAN bus would make planes similarly vulnerable to cyberattack.

To find out, Rapid7 bought avionics from two vendors Kiley declines to name and he quickly discovered he could cause all sorts of trouble. He introduced commands to turn off the autopilot. He changed engine telemetry readouts.

Rapid7 and Kiley spent more than a year discussing his findings with an avionics vendor, FAA, the Department of Homeland Security, and the Aviation Information Sharing and Analysis Center, or A-ISAC, the international membership organization based in Maryland. He also presented his work in 2019 at Defcon, the convention in Las Vegas that typically attracts 20,000 hackers of all stripes.

If the word “hacker” makes you think of somebody under a figurative black hat trying to steal intellectual property or hijack planes, that’s one kind of hacker, but that’s not who Kiley and others interviewed for this article are. They are paid cybersecurity researchers with boundless curiosity and a knack for finding flaws in software or computer networks. Some could be called gray hats when their research isn’t authorized by the organizations they investigate. Others work primarily as ethical hackers, called white-hat hackers, who are hired by an organization to look for vulnerabilities.

“The analogy I draw is to a car guy, somebody who knows everything about 1960s muscle cars, can take an engine apart in a weekend and put it back together with extra horsepower,” says Brad Haines, who’s known in the hacker community by his high school nickname RenderMan, after the Pixar animation software.

Leveraging hackers’ knowledge

For a long time, aviation companies and government

> “An aircraft is pretty much a computer that happens to have wings, two engines and people in the front flying it.”
>
> — **Pete Cooper**, Aerospace Village

▲ **The U.S. Air Force** asked gray-hat hackers at 2019's Defcon to attack software on an F-15.

U.S. Air Force

agencies had little contact with hackers whose scrutiny of networks was not invited. That's beginning to change.

"If we are going to secure this industry, we basically need the help and involvement of everybody," says Remzi Seker, founder and former director of the Cybersecurity and Assured Systems Engineering Center at Embry-Riddle Aeronautical University in Florida. "If a group of hackers wants to help, then the industry needs to look into how we can leverage these people, their energy, their knowledge and their time."

The aviation establishment is listening. The United Nations' International Civil Aviation Organization encourages its member countries to "set up appropriate mechanisms for cooperation with 'good faith' security research."

The Atlantic Council think tank in Washington, D.C., conducted a survey last year and found "strong agreement that good-faith researchers were a positive thing for the aviation industry."

Still, it's not an easy alliance. In the past, hackers felt like aviation companies and government agencies kept them at arm's length privately while publicly dismissing their research. Aviation equipment manufacturers, meanwhile, complained hackers sometimes made exaggerated claims about their ability to breach networks that undermined public confidence in aviation safety.

A little over a year ago, a group of security researchers, pilots and aerospace industry executives created a nonprofit international organization to bridge that divide. They called it the Aviation Village since Defcon is split into villages where attendees delve into various topics, such as automotive cybersecurity. They later renamed their group the Aerospace Village to underscore aviation's growing reliance on satellites for communications and navigation.

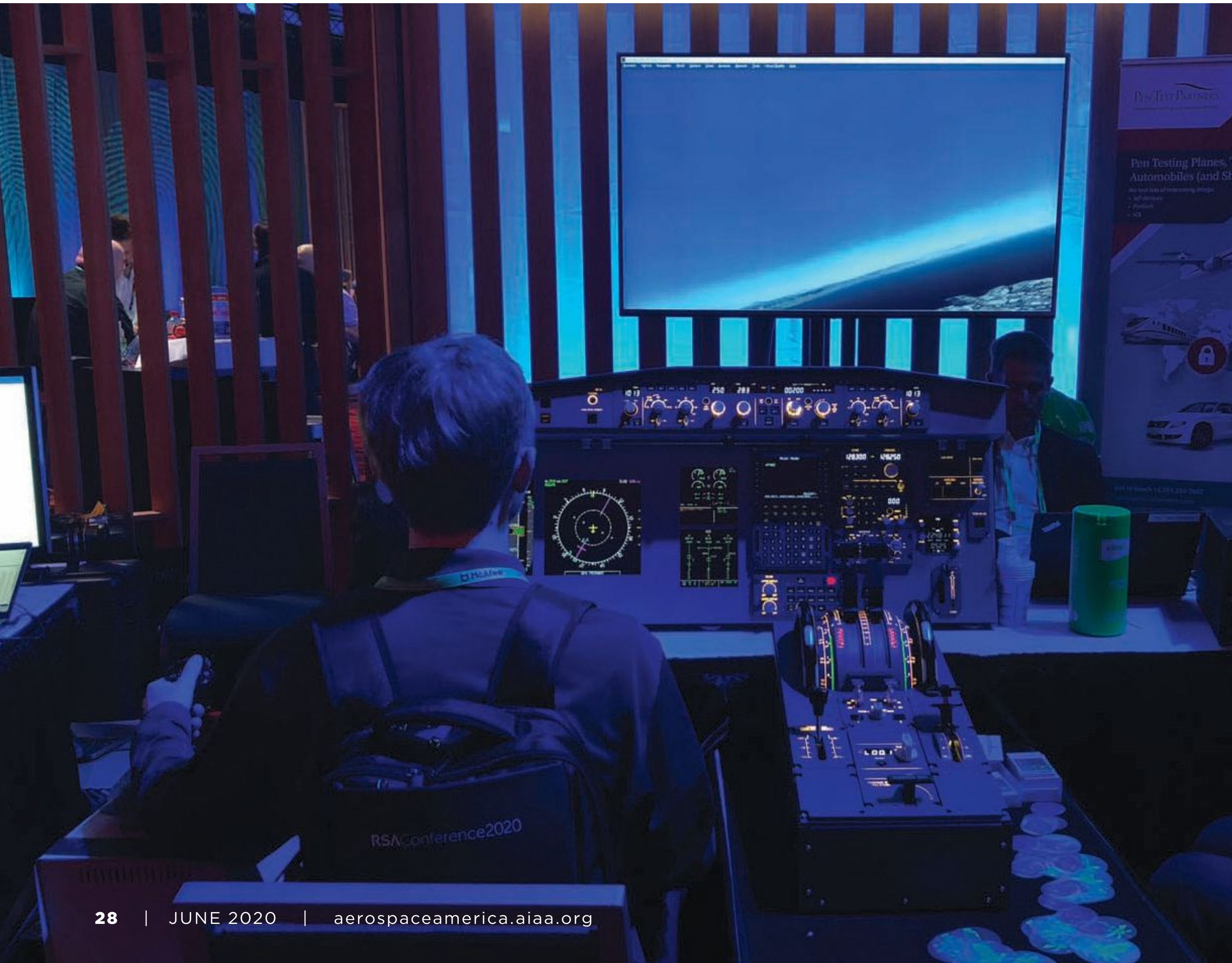
The Aerospace Village is a virtual entity with no physical headquarters. In conference presentations and private meetings, Aerospace Village speakers encourage collaboration and communication with hackers.

"We need to get past stereotypes of the sinister masked hacker or the guy living in his parents' basement so we can find problems and make flying more safe and secure," says Steve Luczynski, a member of the village's board of directors and a former U.S. Air Force fighter pilot. He is now chief information security officer at T-Rex Solutions, an information technology company in Maryland.

New vulnerability

Airplanes were once cut off from ground-based computer networks after takeoff, meaning someone needed physical access to interfere with avionics. Now, airplanes share data in flight with multiple ground networks to get a head start on maintenance needs, offer passenger entertainment and announce their locations.

"An aircraft is pretty much a computer that happens to have wings, two engines and people in the front flying it," says Pete Cooper, Aerospace Village director and a former British Royal Air Force jet pilot who advised the United Kingdom's Ministry of Defense on cybersecurity. "When I'm talking to airlines, I'm trying to get across the message that their aircraft are as much a part of their enterprise architecture as their offices."

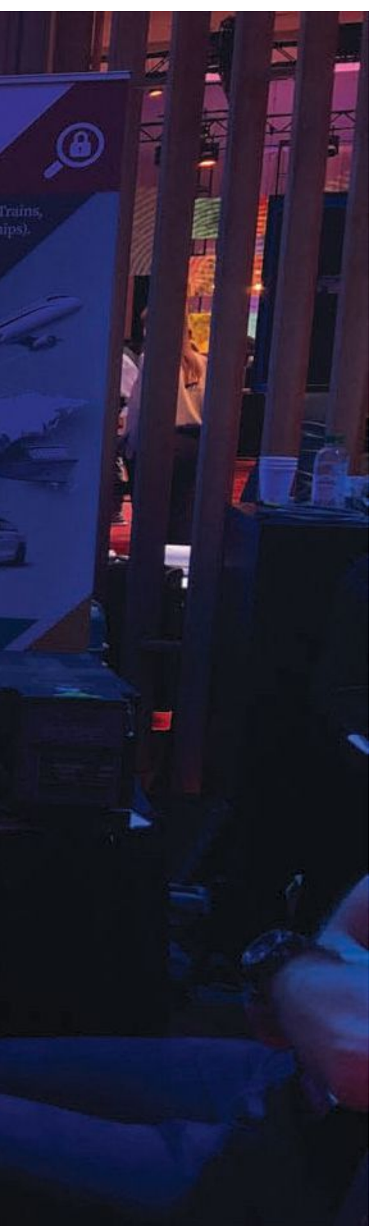


▼ **Cybersecurity** researchers test an Airbus passenger jet simulator in San Francisco at Aerospace Village's RSA conference booth.

Debra Werner

"Hackers are passionate about the craft. When people say a system is secure and protected, if I can find a way to defeat it, I've literally done the impossible. That's kind of cool, and if I can figure out how to defeat it, maybe somebody else can, too."

— Brad Haines, aka RenderMan



Hackers notice the similarity and see planes "as connected devices," says Haines, aka RenderMan.

Haines attracted attention in the aviation world when he gave a talk in 2012 at Defcon about spoofing the outgoing position and identity signals from the FAA-required Automatic Dependence Surveillance-Broadcast transponders on aircraft to give the appearance of more planes flying in an area.

"Hackers are passionate about the craft," Haines says. "When people say a system is secure and protected, if I can find a way to defeat it, I've literally done the impossible. That's kind of cool, and if I can figure out how to defeat it, maybe somebody else can, too."

Haines says he wanted to share his research with aviation companies because he flies a lot and "a certain amount of self-preservation was involved" but he "couldn't figure out how to report it to anyone, so I dropped a bombshell."

Chris Roberts, who was escorted by FBI agents off a United Airlines flight in Syracuse, New York, in 2015 after tweeting about hacking the plane, tells a similar story. Roberts spent years gathering flight manuals, studying wiring diagrams and testing components in his home laboratory to discover vulnerabilities in airplane networks. He says he found troubling links between the in-flight entertainment system on Airbus and Boeing planes and other onboard networks, including flight controls. He says no one took his warnings seriously until his 2015 tweet suggesting he could access the plane's Engine Indicating and Crew Alerting System and release passenger oxygen masks.

"Companies would rather spend money on lawyers and public relations to deny the issue rather than bringing in an outsider to help fix a problem," Roberts says.

Now, the Aerospace Village, Airbus, Boeing and A-ISAC are inviting hackers to share their findings.

At Defcon in 2019, the U.S. Air Force invited hackers at the Aviation Village to break into an F-15 fighter jet's Trusted Aircraft Information Download Station, a device that collects video and sensor data. At 2020's Defcon, which will be online due to the covid-19 pandemic, the Aerospace Village will host Hack-a-Sat, a contest to see who can identify security flaws in an Air Force satellite.

Airbus and Boeing invite researchers to email encrypted summaries of their findings. On its website, Airbus asks researchers to email "a brief description of the issue identified, including what was attempted and the result" to vuln@airbus.com. "If you are able to provide additional information regarding the affected Airbus product, service or offering, it will also be beneficial for our investigation."

At Boeing, email sent to Vulnerability.Disclosure@Boeing.com "gets routed to my organization," says John Craig, Boeing Commercial Airplanes chief engineer for aviation networks and security and A-ISAC board chairman. "These third-party researchers are trying to understand how aviation works. We came to the realization that it is in our best interest to reach out to these folks and see how we can get a responsible interaction on aviation security issues."

In addition, the A-ISAC helps security researchers make contact with companies to ensure responsible disclosure, meaning researchers share information with industry chief information security officers and give companies time to patch software or otherwise shore up network vulnerabilities before making the information public, says Jeffrey Troy, A-ISAC president and CEO.

Giving hackers credit

How and when hackers publish their research is often a sticking point in discussions with companies or government agencies.

Kiley, the CAN bus researcher, spent months seeking approval to publish his findings.

"After many, many back-and-forth conversations with the FAA, the A-ISAC, DHS and one of the vendors, we did the release of the report," Kiley said at the RSA cybersecurity conference in San Francisco in February. "We delayed long enough to make sure that all the industry partners, the airlines, the airframers and everyone involved was aware of this issue."

Aviation experts say those delays are essential because aircraft take a long time to fix. Any potential fix has to be certified by government agencies to ensure the aircraft remain safe to fly, said Ken Munro, partner and founder of Pen Test Partners of Buckingham, England, at the RSA conference.

▲ **Patrick Kiley,** a consultant for cybersecurity firm Rapid7, tells an audience at the 2020 RSA cybersecurity conference in San Francisco about vulnerabilities in CAN bus, a standard for wirelessly linking avionics.

Debra Werner

In the hacking community, the lines between hackers who specialize in accessing computer networks without authorization and penetration testers are often blurred. In reality, there are quite a few gray hats, people who do both, or start out as black hats before earning a living as white hats. Haines' LinkedIn profile, for example, says, "Hacker by birth, security professional by trade."

"Many companies are approached routinely by gray-hat hackers who found vulnerabilities in systems," says Lisa Sotto, a New York attorney who chairs the Global Privacy and Cybersecurity practice at law firm Hunton Andrews Kurth LLP. "They expect direct payment for information, or they ask to be retained by the company for their expertise."

If companies can't afford to pay hackers for their work, they simply offer kudos or acknowledge their efforts. In those cases, according to RenderMan, hackers still come forward, "because notoriety is our bread and butter, very much like publishing for a scientist."

All of this raises the question of legality. Isn't trespassing in a private or government network illegal?

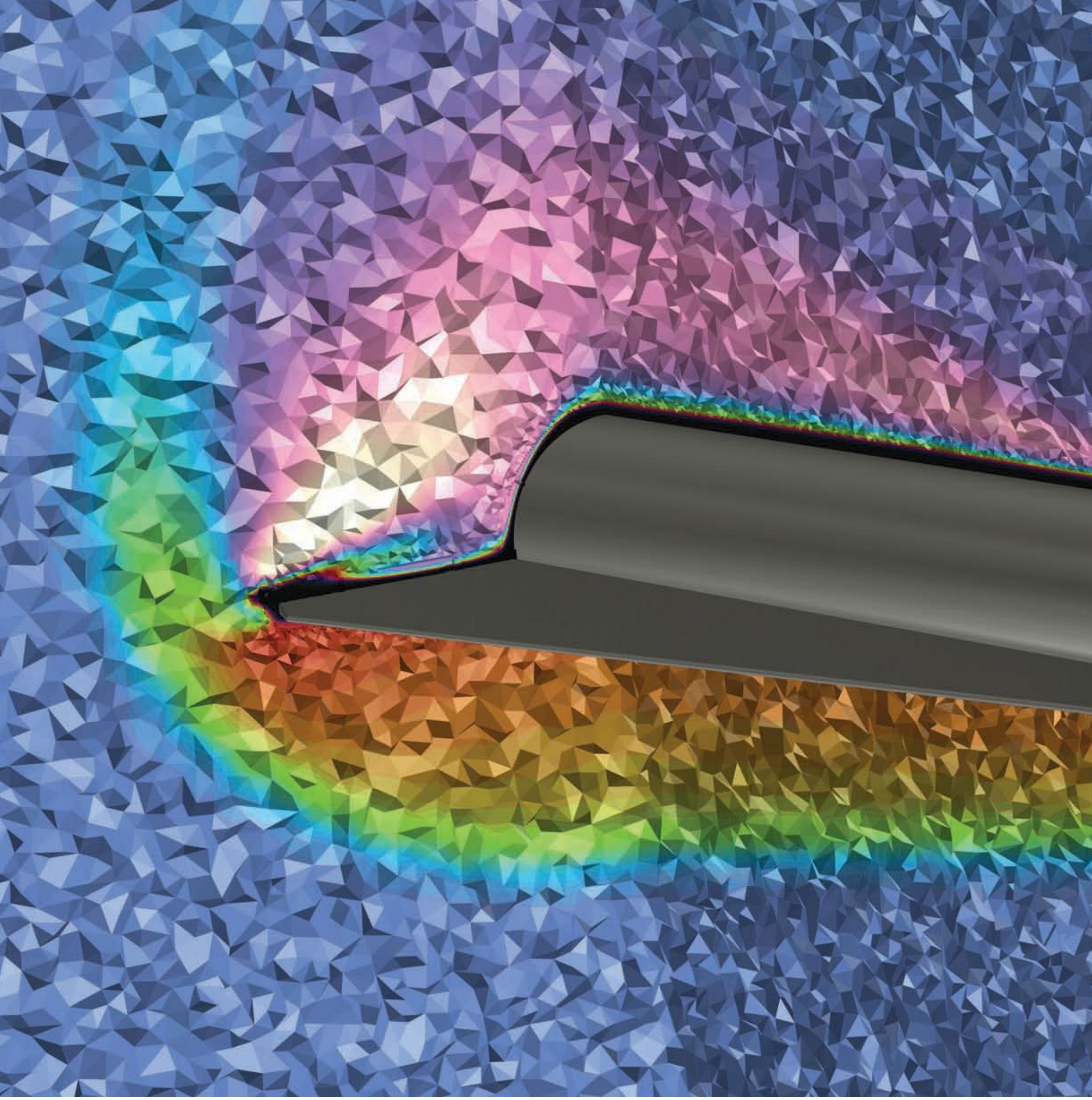
It is illegal if hackers are intentionally intercepting electronic communications but not if they stop right before they cross the line. It's like saying, "I see that there's no lock, I see that the door is ajar, but I'm not walking in," Sotto says.

The type of research the Aerospace Village promotes is far removed from day-to-day operations of airlines and airport networks. Instead the Aerospace Village is encouraging researchers to buy aviation equipment and test it in laboratories.

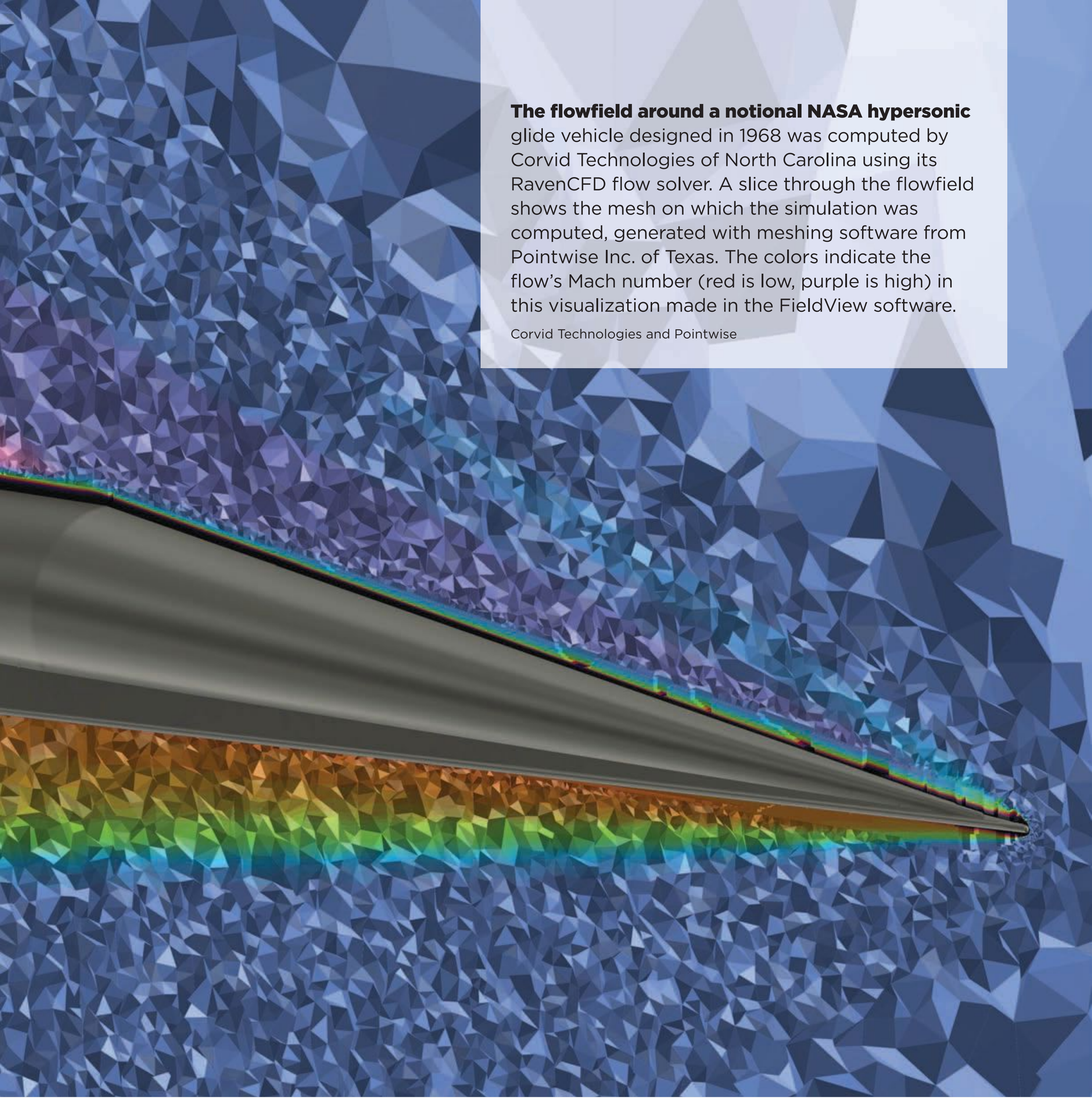
"We would like to see researchers and manufacturers partnering together to leverage the expertise each brings and advance aviation cybersecurity to protect passengers," says Cooper, the Aerospace Village director who runs Pavisade, a cybersecurity consulting firm in London. "It is fantastic that we are gradually starting to see this happen, but it's definitely a journey, as manufacturers see the benefits of working with the research community and researchers start to engage and build trust." ★

"If a group of hackers wants to help, then the industry needs to look into how we can leverage these people, their energy, their knowledge and their time."

— **Remzi Seker**, Embry-Riddle Aeronautical University



MISSILE GAP



The flowfield around a notional NASA hypersonic glide vehicle designed in 1968 was computed by Corvid Technologies of North Carolina using its RavenCFD flow solver. A slice through the flowfield shows the mesh on which the simulation was computed, generated with meshing software from Pointwise Inc. of Texas. The colors indicate the flow's Mach number (red is low, purple is high) in this visualization made in the FieldView software.

Corvid Technologies and Pointwise

The U.S. believes it has made a breakthrough toward closing the gap in hypersonic missile technology it perceives between itself and China and Russia. Some independent observers, however, question whether those countries have, in fact, progressed quite as far as U.S. planners contend. Keith Button spoke to Pentagon officials and independent missile watchers.

BY KEITH BUTTON | buttonkeith@gmail.com

The visual evidence is slight: a photo and a five-second video of a white rocket blasting off into the pitch-black night from a Kauai, Hawaii, launch pad. The U.S. Department of Defense's description of the March flight test is similarly lacking in detail: That the missile launched and flew at a velocity of more than five times the speed of sound to a designated impact point. That's it.

But this flight was an important milestone, according to the Pentagon. After five decades of sporadic research, the hypersonic spending push begun by the Trump administration two years ago has at last nudged a maneuverable hypersonic missile program over the threshold into weapons prototype development.

Perhaps the U.S. isn't hopelessly behind China and Russia on maneuverable hypersonics, if indeed it is significantly behind at all.

The public record tells a murky tale on this question of a missile gap. China and Russia both claim to have already fielded maneuverable hypersonic weapons like the missile the U.S. tested in March — missiles that are boosted to hyperson-

▼ A Common Hypersonic Glide Body was launched from the U.S. Navy's Pacific Missile Range Facility on the island of Kauai, Hawaii, in March.

U.S. Navy

ic speeds by rockets and then hypersonically glide to their targets. Shortly before the March test, Michael Griffin, the under secretary of defense for research and engineering, referred to "rocket boosted hypersonic glide" weapons in an address at the Ronald Reagan Building in Washington, D.C., and he said China and Russia are accumulating "these things by the hundreds and thousands." His office later amended his comments, saying his numbers were meant to include "high-speed conventional weapons, maneuverable or otherwise, that are fielded, in development, or planned." And some independent analysts are skeptical about China and Russia's true maneuverable hypersonic weapon capabilities.

What no one disputes is that the U.S. does not have hypersonic boost-glide missiles fielded.

That's a big deal, because boost-glide or other maneuverable hypersonic missiles could arguably render aircraft, other missiles, naval forces and other traditional military weapons obsolete.

"It's not about the speed," says Thomas Karako, director of the Missile Defense Project at the Center for Strategic and International Studies, or CSIS, in Washington, D.C. While Mach 5 is fast and the start of the hypersonic regime, "it is the trajectory, rather, that circumvents our early warning systems or ability to track it," he says.

The speed difference

Boost-glide missiles would be slower than intercontinental ballistic missiles, which, in a nuclear war, must accelerate out of silos or submarines or mobile land-based launchers to reach the fringes of space. There, they would release multiple cone-shaped warheads to fall toward their targets at Mach 20 to Mach 25. As frightening as they are due to their nuclear payloads, the trajectories of these warheads can be predicted from a missile's early flight. A maneuverable boost-glide missile would fly a similar path toward suborbital space, but after that its flight path would be unpredictable to an air defense system trying to shoot it down. It would glide toward its target with its momentum and could be maneuvered to hug the terrain like a conventional cruise missile does to avoid radar detection. The difference is that it would streak toward its target about 10 times faster.

The U.S. is aiming to field conventionally armed boost-glide hypersonic missiles by 2025, says Mike White, who is in charge of hypersonics in Griffin's office. The missile flown from Hawaii in March was a concept called the Common Hypersonic Glide Body, which is closer to fruition than the decadeslong U.S. research on air-breathing hypersonic missiles that would maneuver to their targets while under continuous propulsion. The U.S. Army and Navy will each take the common body design as the base to develop its own hypersonic missiles: a truck-launched Long-Range Hypersonic Weapon for the Army, with a range of 2,250 kilometers, and a submarine-launched missile called Intermediate Range Conventional Prompt Strike for the Navy, which plans to build prototypes for flight tests through 2024.

Separately, the U.S. Air Force is developing a hypersonic boost-glide missile not related to the Common Hypersonic Glide Body called the Air-Launched Rapid Response Weapon, which would have a range of 925 km. The Air Force is targeting 2022 for deploying the missile, but so far its only flight test has been while attached to a B-52, which was in June 2019.

Big power competitors

PROGRAM	SPONSOR(S)
Air-launched Rapid Response Weapon (ARRW) A maneuverable hypersonic missile based on DARPA's Tactical Boost Glide design. Sources: Congressional Research Service; Center for Strategic and International Studies	United States (U.S. Air Force)
Avangard A 5.4-meter-long maneuverable hypersonic boost-glide weapon under development since the mid-1980s. Once boosted to more than Mach 20 by a ballistic missile, Avangard detaches and glides to a range of at least 6,000 kilometers. Sources: Center for Strategic and International Studies; Nuclear Threat Initiative	Russia (Strategic Missile Forces)
DF-17 Truck-mounted hypersonic boost-glide missile; 11 meters long with a range of 1,800 to 2,500 kilometers. Source: Center for Strategic and International Studies	China (People's Liberation Army)
Common Hypersonic Glide Body A hypersonic boost-glide design that the Army will turn into the Long-Range Hypersonic Weapon and the Navy will turn into the Intermediate Range Conventional Prompt Strike missile. Source: U.S. Department of Defense	United States (U.S. Navy and U.S. Army)
Hypersonic Air-breathing Weapon Concept A hydrocarbon-fueled, supersonic combustion ramjet (air-breathing) hypersonic missile that could be launched from an aircraft. Sources: DARPA; Aerospace America reporting	United States (DARPA-U.S. Air Force)
Hypersonic Conventional Strike Weapon A hypersonic boost-glide missile, although the program has been canceled. Sources: Center for Strategic and International Studies, Aerospace America reporting	United States (U.S. Air Force)
Intermediate Range Conventional Prompt Strike Missile This conventional (non-nuclear), submarine-launched hypersonic boost-glide missile would attack high-value or fleeting targets and would be developed from the Common Hypersonic Glide Body. Sources: Congressional Research Service; Center for Strategic and International Studies	United States (U.S. Navy)
Long-Range Hypersonic Weapon This conventional truck-launched hypersonic missile would be developed from the Common Hypersonic Glide Body. Sources: Dynetics, Lockheed Martin, Center for Strategic and International Studies	United States (U.S. Army)
Starry Sky-2 A ground-launched, rocket-boosted, delta-shaped hypersonic glide plane. Source: Nuclear Threat Initiative	China (People's Liberation Army)
Tactical Boost Glide The missile is a precursor to the Air Force's Air-launched Rapid Response Weapon, which will carry the Tactical Boost Glide re-entry vehicle and potentially other missiles. Sources: Congressional Research Service; Raytheon; U.S. Department of Defense	United States (DARPA-U.S. Air Force)
Tsirkon An 8- to 11-meter-long hyspersonic missile to be launched from a ship or submarine. It would reach Mach 9 and travel 1,000 kilometers. It has two stages: a solid-fuel rocket booster and a scramjet powered, air-breathing engine. Source: Nuclear Threat Initiative	Russia (Russian Navy)

Hypersonic missile projects of China, Russia and the United States. Chinese and Russian weapons would be conventionally or nuclear armed. U.S. weapons would be conventional.

WHAT'S AHEAD	STATUS
Deployment scheduled for 2022.	The Air Force and contractor Lockheed Martin performed a "captive flight test" of the missile in June 2019 with it attached to a B-52 in flight.
No information available.	In December 2019, Russia said the Avangard had "assumed combat duty," according to Tass news agency. Since 1990, 14 flight tests have been reported. Analysts, including one for a U.N. agency, consider only a few of those to be successful, such as one in December 2018 atop an intercontinental ballistic missile. No images of the weapon have been released.
No information available.	Displayed for the first time to the public in a military parade in October 2019. Western analysts are unsure whether the missile is in service.
Navy developing new booster.	Pentagon conducted a second flight test in March 2020. Dynetics Technical Solutions of Alabama is lead contractor for the team with General Atomics Electromagnetic Systems of San Diego, Lockheed Martin and Raytheon to build a new version of the glide body for tests and fielded prototype.
Prototype scheduled for mid-2020s.	HAWC test flights were planned for 2020; coronavirus shutdowns have delayed those plans.
Some researchers hope to get back to this canceled project.	The U.S. Air Force budget request for 2021 canceled the program. Air Force planes could carry twice as many ARRWs as Hypersonic Conventional Strike Weapons.
Deployment scheduled for 2028.	To be fielded on U.S. Navy Virginia-class submarines. Lockheed Martin was awarded an $846 million contract as the prime contractor to design, develop and build.
Prototype missile with experimental batteries to be fielded in 2023.	Received first funding in 2020 to develop a prototype missile and experimental batteries. In August 2019, the Army awarded a $347 million contract to Lockheed Martin as the prime contractor to design the weapon system integrator.
No information available.	The plane reached Mach 6 in an August 2018 test and completed "extreme maneuvers" and landed intact, according to a review of Chinese-state-sponsored media accounts by the Nuclear Threat Initiative.
No information available.	In 2019, DARPA awarded Raytheon Missiles and Defense a $63 million contract to develop the Tactical Boost Glide, and the two parties completed baseline design review of the missile.
Deployment is scheduled for 2025.	Test launched from a ship in January 2020; hit a target at 500 kilometers.

If the U.S. is behind in the arms race for boost-glide or other maneuverable hypersonic missiles, some experts don't believe the gap to be extreme.

▲ **A U.S. hypersonic** Air-launched Rapid Response Weapon, or ARRW, was carried on the wing of a B-52 in 2019 to measure its drag and vibration effects. The weapon carried sensors in place of explosives and was not released.

U.S. Air Force/Christopher Okula

Hypersonics guidance is "tricky"

Russian Defense Minister Sergei Shoigu reported last December that its Avangard boost-glide design was operational: a 5.4-meter-long hypersonic weapon boosted by a ballistic missile to a range of 6,000 km, and capable of carrying either a conventional or nuclear warhead. The weapon "heads to target like a meteorite, like a fireball," President Vladimir Putin said of Avangard in 2018.

But the Avangard's testing history is less impressive, according to the Nuclear Threat Initiative, a Washington, D.C.-based nonpartisan nonprofit focused on preventing global catastrophes.

Only three of the Avangard's 14 flight tests that were reported since 1990 were considered successful, the group says, citing Pavel Podvig, senior researcher for the United Nations Institute for Disarmament Research.

China publicly displayed its DF-17 boost-glide missile for the first time in a military parade last October. The truck-mounted missile is 11 meters long with a range of up to 2,500 km, capable of carrying either non-nuclear or nuclear warheads, according to the CSIS website. CSIS says the service readiness of the missile is unclear.

The decision by China and Russia to note the potential of their weapons to carry nuclear explosives caught the eye of analysts.

That could be interpreted as a sign that neither country's weapon is as accurate as what would be required to destroy a target with a conventional warhead with a much smaller blast radius, says Jill Hruby, former director of Sandia National Laboratories and a consultant for the Nuclear

"We've bumped up against that transition gap or glass ceiling for getting over the hump to building real systems. I think we're over that hump."

— Mike White, U.S. Department of Defense

Threat Initiative.

"Hypersonics guidance is tricky, to be sure. So if they haven't perfected their guidance system and it's not very accurate, they would be more tempted to deploy a nuclear system if they want a deterrent; if they really want a war-fighting capability," Hruby says. China's DF-17 seems to be a more legitimate concern for the U.S. than Russia's Avangard based on the number of its flight tests — at least nine since 2014, of which only one was deemed a failure, she says.

Iain Boyd, who tracks hypersonics research as a professor and national security faculty director at the University of Colorado Boulder, is also skeptical of the capabilities of China's and Russia's maneuverable hypersonic missile arsenals. "There's a big difference between having the kind of test flights that have been documented with China and Russia and having the capability to predictably launch and hit targets," he says. "There's a number of steps between those two things."

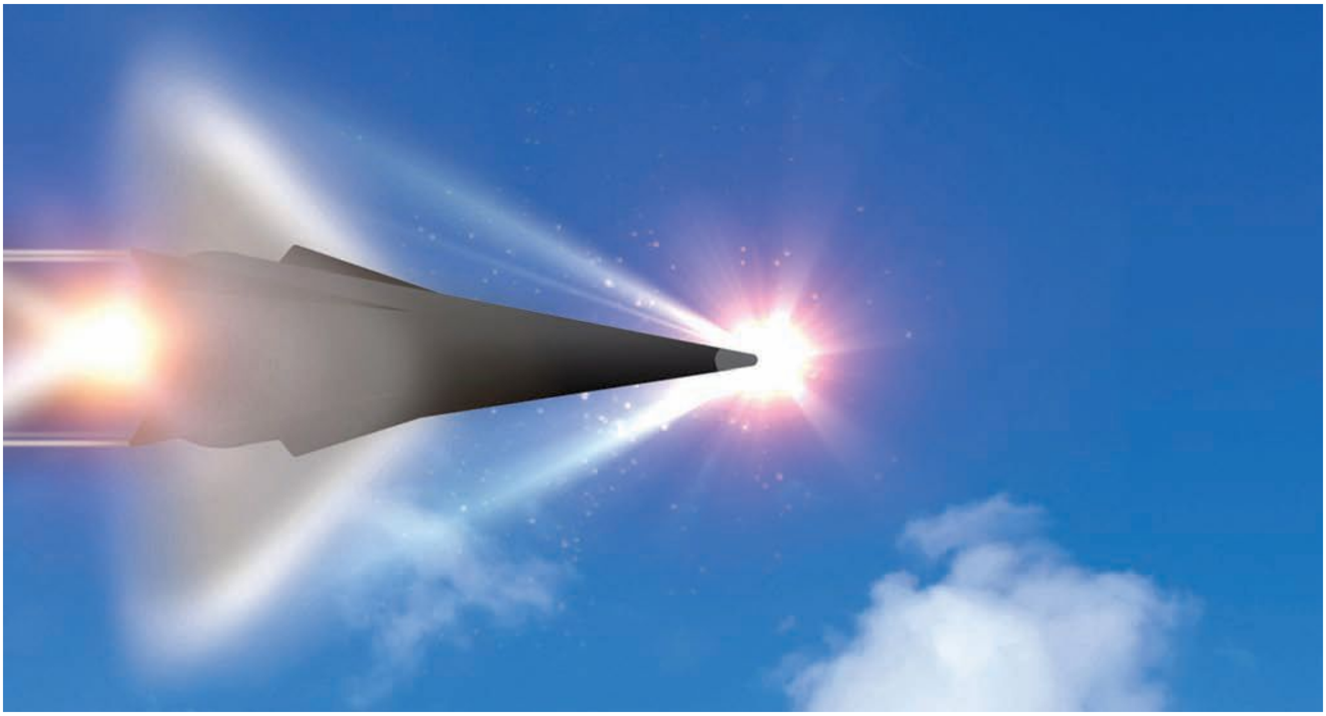
China does have a considerable research advantage in hypersonics, based on publicly available academic peer-reviewed articles, says Boyd, who has tracked the hypersonics research figures by country since 2005. Over the last five years, Chinese researchers have published 1,334 such articles, compared to 418 for American researchers and 133 for Russian researchers.

In recent years, Chinese researchers have published hundreds of papers on guidance, navigation and control of hypersonic vehicles, which seems to show that their understanding of hypersonic flight has grown advanced, while the U.S. has published very little on these topics. "It's kind of an indication that they're starting to think: 'OK; we can now fly a hypersonic vehicle. We can now build and design a hypersonic vehicle. What are we actually going to do with it?'" Boyd says. "It's an indication that they're clearly in that part of the development cycle where they're really thinking hard about what can they actually do with this technology."

China has also poured money into hypersonic wind tunnels over the last 15 years, building 30 to 40 new hypersonic test facilities, compared to five or six in the U.S., Boyd adds.

But academic research can take 10 or even 15 years to translate into fielded flight technology, according to Boyd, and he's not convinced that the U.S. is necessarily behind China or Russia in hypersonics. "Someone's going to declare victory and have the first hypersonic thing fielded, but it will be limited in capability. That doesn't mean that that country has won, so to speak, the hypersonic race," he says.

The U.S. plan to close the presumed hypersonics gap starts with pouring money into research and development. Hypersonics spending is difficult to track, because the funding is contained in multiple locations of the defense budget, but an analysis by the CSIS Missile Defense Project shows that after



▲ **A conceptual** hypersonic glide body.

Dynetics

spending $100 million in fiscal 2016, $200 million in 2017 and $700 million in 2018, the Pentagon spent $1.3 billion in fiscal 2019 and will spend nearly $2 billion in 2020. This would be followed annually by requests for $2.4 billion, $2 billion, $1.9 billion, $1.4 billion and $1.4 billion.

Developing hypersonics workforce

Included in that plan is a doubling of the funding for hypersonics research at U.S. universities, establishing a university consortium with the Department of Defense to encourage more applied research. Besides advancing university research more quickly into working hypersonic vehicles, the increased university funding would help develop the future workforce for hypersonics fields, Boyd says. The hypersonics workforce is another perceived gap between the U.S. and China, correlated to the numbers of university students working on the published academic research. "If the U.S. is really going to build a lot of these things, then the Lockheeds and the Raytheons need thousands of engineers to work on hypersonics," he says.

The U.S. will spend $14 billion over the next several years to build and demonstrate its various hypersonic weapon prototypes, says White, the hypersonics chief. The U.S. is planning at least 40 flight tests of hypersonic missiles in the next several years, including several more in 2020, White says. He declined to provide any details about the planned tests.

This comes after years of only research-and-development-level flight tests, following testing in the 1960s of the crewed, rocket-powered X-15 hypersonic aircraft, which logged 199 flights. With the March test of the Common Hypersonic Glide Body, the U.S. is no longer stuck in a research-and-development mode with hypersonics, White says. For years, "we've bumped up against that transition gap or glass ceiling for getting over the hump to building real systems," he says. "I think we're over that hump." Another area where the U.S. could be poised to advance in the hypersonics race is with air-breathing. As for air-breathers, no country has fielded those yet, and the U.S. wants to advance here too. Air-breathers, powered by scramjet engines, could be smaller, lighter and more maneuverable than boost-glide missiles because they wouldn't have to carry solid fuel for rocket engines. "They fit on fighters and they fit on bombers in numbers, so you might fit eight times more cruise missiles on a B-52 than you would fit on the boost-glide systems," White says. He is aiming to have an air-breathing prototype flight by the mid-2020s.

Ultimately, new hypersonic missiles will add an incremental capability to the existing arsenals of ballistic and cruise missiles, which already have similar capabilities to the new hypersonic missiles for avoiding detection and swiftly hitting distant targets, says Karako of CSIS. But that increment can be significant.

New hypersonic missiles are "neither all hype — it's not meaningless — nor is it completely new and different," he says. His analogy: A new tank that has only a slightly longer artillery range than an old tank still has a considerable advantage. "If I'm fighting tank to tank, that extra range means all the difference in the world." ★

The safety side of visualization

The digital visualization revolution unfolding in general aviation is already showing safety dividends. For this trend to continue, the right training and proper mindset will be required. Jan Tegler explains.

BY JAN TEGLER | wingsorb@aol.com

Raymond Wagner, chief pilot for Take Flight Aviation in rural New York, was approaching Orange County Airport with a student pilot at the controls when he noticed the student ignoring the localizer needle on the instrument panel in favor of a nearby display showing a virtual rendering of the world outside his cockpit.

Wagner, of course, would not let matters become dangerous, but the student's total focus on the synthetic vision system, or SVS, was worrisome, because the localizer needle helps a pilot line up with a runway, such as the one they were headed for in their Diamond DA40. Synthetic vision systems provide valuable awareness about terrain, weather and air traffic, but they do not tell a pilot everything he needs to know to land safely. Over reliance on SVS could lead to a missed approach or, in theory, to a deadly accident.

In fact, the tendency of students to fixate on their SVS display is so common that Wagner and fellow instructor Merle Minks turn off the display on initial instrument training flights to force students to use the localizer needle.

Those in the avionics and training industries have firm ideas for how to deal with those risks and ensure that the technology continues to improve safety among general aviation pilots.

The SVS technology, and the weather-piercing enhanced vision systems, or EVS, that are starting to join them on some aircraft, received a boost from FAA a little over a decade ago. The agency began sponsoring research on the technology at MITRE Corp.'s Aviation Integration Demonstration and Experimentation for Aeronautics Laboratory. The main goal was to see how the technology could support the agency's equivalent visual operations initiative, the aim being

A pilot approaching a runway would see the view on the left when looking out the cockpit with his naked eyes. At right is what he would see in the head-up display of the Collins Aerospace combined vision system.

Collins Aerospace

to safely narrow the separation among aircraft during instrument-only flying so it is equivalent to the separation when visibility is good.

FAA has only partially achieved equivalent visual operations, but as it turns out, SVS and EVS are doing more than empowering air traffic controllers to safely pack aircraft closer together in the sky. “There’s a greater good,” says Brian Ast, who leads human factors engineering from Garmin’s company headquarters in Kansas.

Reducing terrain accidents

One benefit in general aviation has been a reduction in cases of CFIT, or controlled flight into terrain, when a pilot does not realize his aircraft’s dangerous course until the last moment, if ever. Particularly vulnerable to CFIT are pilots who are rated to fly only in good visibility under visual flight rules as opposed to those rated to fly in poor visibility under instrument-flight rules. “Let’s say a VFR pilot inadvertently flies into clouds. The pilot can use an SVS to safely turn around and fly out of the clouds. And maybe he decides to make a 180-degree turn to the right instead of the left because with the SVS you can see a representation of mountainous terrain or an obstacle over there,” says Ast.

Jens Hennig of the General Aviation Manufacturers Association in Washington, D.C., says the history of SVS is starting to prove the benefit. “If you look at when installed avionics and tablets with flight information like SVS first started to become available in general aviation around 2006, you’ll see that this is when we finally started seeing certain fatal accident categories such as CFIT start declining.”

Specifically, the rate of fatal general aviation accidents per 100,000 flight hours fell to 0.05 in 2016, down from 0.12 in 2008, according to an analysis released by the General Aviation Joint Steering Committee, an industry-government group founded in 1997 under FAA’s Safer Skies Initiative.

“That’s a decline of CFIT accidents by more than half in eight years, a good decrease,” says Hennig.

Advocates of SVS are anxious to learn from the National Transportation Safety Board whether the technology was aboard the Sikorsky S-76B helicopter that crashed near Calabasas, California, in January, killing Kobe Bryant and eight others.

“You wonder if they had better terrain awareness in that aircraft, would that have been helpful?” says author and pilot Tom Haines of the Aircraft Owners and Pilots Association.

If Bryant’s pilot did not have SVS aboard it would not be surprising. Synthetic vision is not yet widely installed in helicopters, although it is common in business jets, turboprops and fixed-wing general aviation aircraft and is coming soon to commercial airliners.

Airline pilots rely on EVS

As for EVS, airline pilots are the primary users of the technology. Video cameras on a plane’s nose or wing are tuned to detect invisible thermal radiation and project scenes of terrain and obstacles in green shading on a glass panel known as a combiner positioned in front of the windscreen. In some versions, millimeter-wave radars integrated with the cameras pierce fog, smog and clouds. Trained to fly on instruments, professional pilots rely especially on EVS with its head-up display to help them take off, land and navigate in all kinds of weather conditions, day or night.

Pilots with proper training and FAA authorization can land Gulfstream business jets equipped with the company’s enhanced vision flight system “with sole reference to the EVS image versus natural vision,” says Jeff Hausmann, Gulfstream Aerospace Corp.’s director of advanced flight decks.

Even when a pilot can’t see a runway with his eyes, he can look through an EVS to see an image of the runway with the flight symbology overlaid on it. This view can guide the pilot almost to touchdown. The final touchdown and the subsequent rollout or slowing would most likely be performed by the pilot with his or her own eyes, because FAA regulations for EVS require 305 meters of runway visual range — the distance over which a pilot can see markings delineating the runway.

Collins Aerospace’s marketing manager for head-up vision systems, Grant Blythe, says airlines are choosing EVS for new jets they’re adding to their fleets. The company’s EVS is available for Boeing’s 737 NG and MAX models. Blythe adds that the company is seeing particular interest for its EVS among Asian airlines.

“In Beijing or Dehli there’s ever-present smog,” Blythe says. “It causes a lot of problems for airplanes there, and the EVS technology is magical for seeing through that and solving their issues.”

Collins also is supplying SVS and EVS as part of a tailored avionics package for the Lockheed Martin X-59 experimental supersonic plane that is the focus of NASA’s Low Boom Flight Demonstration program aimed at quieting supersonic aircraft. Designed without cockpit windows to help minimize noise-producing shockwaves at supersonic speed, the X-59’s lack of natural forward vision means pilots will be totally reliant on SVS and EVS. Collins’ EVS will be displayed on a screen in the X-59’s instrument panel rather than a head-up display.

Blythe says the systems will enable X-59 pilots to land in “nearly all conditions.”

Training GA pilots

For general aviation pilots, practice and self-discipline may be the key to staying on the right side of the risk-benefit equation, industry officials say.

▲ **NASA’s planned X-59** supersonic aircraft, shown in an illustration, should produce no more than a sonic thump in part because of a nose design that eliminates cockpit windows. The pilot will rely on synthetic and enhanced views displayed on the instrument panel.

Lockheed Martin

"The new and novel is always a mind-grab. It's almost overwhelming when you look at a display and see through clouds, but as you learn it and become accustomed to it, you use it more and more effectively."

— **Ric Peri**, Aircraft Electronics Association

Flight instructors will play a large role and right now many "have a lot of homework to do" to gain enough knowledge to teach student and experienced pilots about the capabilities of vision systems and avionics, says John Niehaus a certified flight instructor, Learjet charter pilot and director of program development for the National Association of Flight Instructors. "You almost need to create an additional course to fully understand the capabilities."

Niehaus notes that synthetic vision systems are part of avionics packages on many of the planes in which instructors teach. Two- and four-passenger private planes including Diamond Aircraft's DA 40 and Cessna's classic 172 can be purchased from the factory with the technology.

Ric Peri, the Aircraft Electronics Association's expert on government and industry affairs, says the avionics industry is aware that there may be a need for more training.

"The new and novel is always a mind-grab," Peri says. "It's almost overwhelming when you look at a display and see through clouds, but as you learn it and become accustomed to it, you use it more and more effectively."

Peri reasons that there is "a balance to strike" in adopting vision systems. "Do I need one if I'm a pilot flying a Cessna 182 around the patch? Probably not, but if I'm going cross-country or flying in congested airspace it really helps."

When a pilot does decide to install SVS or buy an aircraft with the technology on it, he must be judicious about how much reliance he places on it. "They can suck you right in," says Haines. "I've been mesmerized and see it all the time in other pilots who are continuing to focus on the displays even on nice days when you can see well outside."

Haines suspects that the flight training he received decades ago in aircraft equipped only with analog instruments reminds him to look outside of his aircraft more often than younger pilots might. He understands the temptations when he flies his modern Beech A36 Bonanza.

"I've got synthetic vision with a flight path marker," says Haines. "When you're flying an IFR approach, it's almost like cheating. You basically put the green flight path marker on the end of the runway and fly to it. You've got to pay attention to altitude, but it is very helpful to those of us who fly for transportation and have the need to get places."

According to Niehaus, for VFR and instrument-rated pilots there's a fine line between teaching them to take advantage of the benefits of vision systems and having them become overconfident because of what they have.

"A good instructor will say that just because you see the terrain or a thunderstorm on your screen doesn't mean you have all the information you need. Look outside, make sure you understand what's in front of you."

Blythe says that vision systems "are so intuitive for the way the brain processes images" that they

▲ **The Symmetry Flight** Deck in the Gulfstream G700 has dual head-up displays.

Gulfstream

can return pilots' situational awareness with a glance if they get disoriented. The downside is that they "are so compelling" that pilots may rely on them too much.

Niehaus says students and experienced pilots transitioning into cockpits with SVS or EVS, which is becoming available for general aviation planes too, tend to "look at the fun new toys instead of looking outside." He adds that he has seen pilots "staring at the blobs of bad weather on an SVS display when in reality they're flying right into what they're trying to avoid because they're not looking outside."

"Proper training is very important," says Roger Dykmann, who directs sales for BendixKing, an avionics maker for general aviation aircraft based in Albuquerque, New Mexico. "We encourage pilots to evaluate their panel requirements for their style of flying, make educated decisions about how to equip their aircraft and then properly train for that equipment."

So far, aircraft and avionics manufacturers haven't incorporated cues in vision systems to remind general aviation pilots to keep their eyes out of the cockpit when possible. For now, says Ast, instilling the importance of visual engagement whenever possible should be done in training by "your flight instructor, safety pilot or whoever it may be trying to keep you safe."

But Ast thinks cues and "those types of improvements will come" as the cost of the avionics go down. "That's where the industry needs to be headed now," he concludes.

For airline pilots, Collins Aerospace has developed a laptop-based virtual reality trainer to help them get comfortable with looking through EVS head-up displays to perform approaches, landings and takeoffs before they go through instruction on airlines' full-motion simulators where training time is expensive and limited. The trainer's software can also render high fidelity SVS images and could be adapted as an SVS training tool.

"Having the ability to practice procedures, to transition from a synthetic vision or enhanced vision image to natural vision is a real advantage," Blythe says.

Hennig of the manufacturers group says synthetic vision systems and someday maybe even enhanced vision systems are on their way to becoming a standard component of general aviation avionics and that pilots will adapt to them as they have to new technology throughout aviation history.

"There's data to show there's always someone who uses technology incorrectly, but I also have data where you see the drop off of accidents if they use it properly," he says. ★

AIAA Bulletin

DIRECTORY

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

To join AIAA; to submit address changes, member inquiries, or renewals; to request journal fulfillment; or to register for an AIAA event. Customer Service: 800.639.AIAA (U.S. only. International callers should use 703.264.7500).

All AIAA staff can be reached by email. Use the formula first name last initial@aiaa.org. Example: 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 / Michele McDonald, ext. 7542 • Continuing Education / Jason Cole, ext. 7596 • Corporate Programs / Nancy Hilliard, ext. 7509 • Editorial, Books and Journals / Heather Brennan, ext. 7568 • Exhibits and Sponsorship / Chris Semon, ext. 7510 • Honors and Awards / Patricia Carr, ext. 7523 • Integration and Outreach Committees / Nancy Hilliard, ext. 7509 • Journal Subscriptions, Member / 800.639.AIAA • Journal Subscriptions, Institutional / Online Archive Subscriptions / Michele Dominiak, ext. 7531 • K–12 Programs / Sha'Niece Simmons, ext. 7590 • Media Relations / Michele McDonald, ext. 7542 • Engage Online Community / Luci Blodgett, ext. 7537 • Public Policy / Steve Sidorek, ext. 7541 • Section Activities / Lindsay Mitchell, ext. 7502 • Standards, Domestic / Hilary Woehrle, ext. 7546 • Standards, International / Nick Tongson, ext. 7515 • Technical Committees / Angie Lander, ext. 7577 • University Programs / Michael Lagana, ext. 7503 • Young Professionals Programs / Alex D'Imperio, ext. 7536

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

15–19 JUNE 2020

Virtual Event

The 2020 forum has gone virtual! Discover how we can transcend traditional collaborations to overcome current challenges, network and exchange ideas with attendees, and access nearly 1,000 on-demand technical presentations.

aiaa.org/aviation

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2020			
15–19 Jun	AIAA AVIATION Forum	VIRTUAL EVENT	7 Nov 19
8–31 Jul	Design of Electrified Propulsion Aircraft Course	Online (aiaa.org/events-learning/online-education)	
9–10 Jul	OpenFOAM® CFD Foundations Course	Online (aiaa.org/events-learning/online-education)	
16 Jul	CANCELLED: 2020 AIAA Fellows Dinner	Crystal City, VA	
17 Jul	CANCELLED: 2020 AIAA Aerospace Spotlight Awards Gala	Washington, DC	
5–28 Aug	Introduction to Multiscale Modeling of Composite Structures and Materials Course	Online (aiaa.org/events-learning/online-education)	
9–13 Aug*	2020 AAS/AIAA Astrodynamics Specialist Conference	South Lake Tahoe, CA	10 Apr 2020
15–22 Aug*	POSTPONED TO 28 JAN–4 FEB 2021: 43rd Scientific Assembly of the Committee on Space Research and Associated Events	Sydney, Australia (cospar2020.org)	14 Feb 20
22–23 Aug	5th AIAA Propulsion Aerodynamics Workshop (PAW05)	New Orleans, LA	
22–23 Aug	Design and Operations of Composite Overwrapped Pressure Vessels (COPV) Course	New Orleans, LA	
22–23 Aug	Fundamentals of Python Programming with NumPy for Aerospace Engineers Course	New Orleans, LA	
22–23 Aug	Liquid Rocket Engines: Emerging Technologies in Liquid Propulsion Course	New Orleans, LA	
22–23 Aug	Missile Propulsion Course	New Orleans, LA	
24–26 Aug	AIAA Propulsion and Energy Forum	New Orleans, LA	11 Feb 20
9 Sep–9 Oct	Hypersonic Flight Vehicle Design and Performance Analysis Course	Online (aiaa.org/events-learning/online-education)	

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.).

14–18 Sep*	32nd Congress of the International Council of the Aeronautical Sciences	Shanghai, China (icas.org)	15 Jul 19
15 Sep–15 Oct	Liquid Rocket Engines: Emerging Technologies in Liquid Propulsion Course	Online (aiaa.org/events-learning/online-education)	
24 Sep–12 Nov	Design and Operation of Composite Overwrapped Pressure Vessels Course	Online (aiaa.org/events-learning/online-education)	
26–27 Sep*	CEAS-ASC Workshop 2019 on “Advanced Materials for Aeroacoustics”	Rome, Italy	
11–15 Oct*	39th Digital Avionics Systems Conference (DASC)	San Antonio, TX (https://2020.dasconline.org/)	
12–14 Oct*	71st International Astronautical Congress (The CyberSpace Edition)	(iac2020.org)	
29 Oct–1 Nov*	37th International Communications Satellite Systems Conference (ICSSC 2020)	Okinawa, Japan (kaconf.org)	15 May 19
16–18 Nov	ASCEND Powered by AIAA	Las Vegas, NV (ascend.events)	31 Mar 20
25–26 Nov	AIAA Region VII/Sydney Section Student Conference	Sydney, NSW, Australia	6 Oct 20
2021			
9–10 Jan	1st AIAA CFD Transition Modeling Prediction Workshop	Nashville, TN	
9–10 Jan	2nd AIAA Workshop for Multifidelity Modeling in Support of Design & Uncertainty Quantification	Nashville, TN	
9–10 Jan	1st AIAA Stability and Control Prediction Workshop	Nashville, TN	
11–15 Jan	AIAA SciTech Forum	Nashville, TN	8 Jun 20
28 Jan–4 Feb*	43rd Scientific Assembly of the Committee on Space Research and Associated Events	Sydney, Australia (cospar2020.org)	14 Feb 20
31 Jan–4 Feb*	31st AAS/AIAA Space Flight Mechanics Meeting	Charlotte, NC (http://space-flight.org)	
6–13 Mar*	2021 IEEE Aerospace Conference	Big Sky, MT (www.aeroconf.org)	
12–14 Apr*	55th 3AF Conference on Applied Aerodynamics (AERO2020+1)	Poitiers, France (http://3af-aerodynamics2020.com)	
20–22 Apr	AIAA DEFENSE Forum	Laurel, MD	
5–7 May*	6th CEAS Conference on Guidance Navigation and Control (2021 EuroGNC)	Berlin, Germany (https://eurognc2021.dglr.de)	
31 May–2 Jun*	28th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia (elektropribor.spb.ru/en)	
5–11 Jun	AIAA AVIATION Forum	Washington, DC	
22–25 Jun*	ICNPAA 2021: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
9–11 Aug	AIAA Propulsion and Energy Forum	Denver, CO	
25–29 Oct*	72nd International Astronautical Congress	Dubai, UAE	
15–17 Nov	ASCEND Powered by AIAA	Las Vegas, NV	

● AIAA Continuing Education offerings

**Meetings cosponsored by AIAA. Cosponsorship forms can be found at aiaa.org/Co-SponsorshipOpportunities.*

Nominations for AIAA President-Elect Being Accepted Through 17 July

The AIAA Executive Nominating Committee (ENC) will compile a list of potential nominees for the position of AIAA President-Elect. This list will include nominees who will be selected to go to the next step of competency review and interview held by the nominating committee. The ENC will select specific candidates for the position who will be voted on by the AIAA membership. The final slate of candidates will be publicized by December 2020 for the election that will be held January/February 2021. AIAA members may nominate members qualified for the open position by submitting a nomination **no later than 1800 hrs EDT, 17 July 2020**.

To nominate an AIAA member in good standing for AIAA President-Elect, please submit the nominee's bio and/or CV, history of AIAA activities and/or engagement with other professional societies, and a statement from the nominee of willingness and ability to serve if elected.

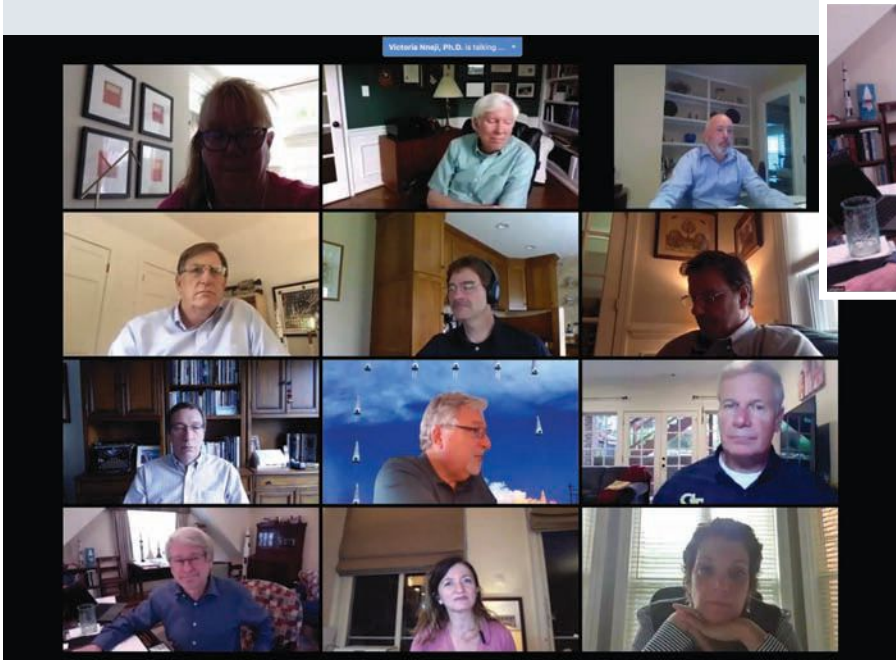
Please submit nominations directly to Christopher Horton, AIAA Governance Secretary, chrish@aiaa.org, no later than 1800 hrs EDT, 17 July 2020.

Nominations for AIAA Directors Being Accepted Through 17 July

The AIAA Council of Directors Nominating Committee (CNC) will compile a list of potential nominees for the open Director positions on the AIAA Council of Directors. This list will include nominees who will be selected to go to the next step of competency review and interview held by the nominating committee. The nominating committee will select specific candidates for the open Director positions who will be voted on by the AIAA membership. The final slate of candidates will be publicized by December 2020 for the election that will be held January/February 2021.

Nominations are being accepted for Regional Directors, Integration and Outreach Group Director, and Technical Group Directors for the term beginning May 2021–2024. AIAA members may nominate members

On 18 May, during the Joint Annual Meeting of the Council of Directors and Board of Trustees the gavel was virtually transferred to AIAA President Basil Hassan from Immediate Past President John Langford. Below, Langford thanks the Board and Council.



Go to AIAA's YouTube channel (https://www.youtube.com/watch?v=3PfYMmRLT9c&t=3s) to watch AIAA's tribute video to John Langford's tenure.

qualified for the open position by submitting a nomination **no later than 1800 hrs EDT, 17 July 2020**.

Regions coordinate the activities of geographically related sections to facilitate cooperative efforts between the various geographical areas. A Regional Director shall lead each region. The voting members who belong to that region shall elect the Regional Director for that region. The Regional Director for each group shall be a member of the Regional Engagement Activities Division (READ) as well as a delegate to the Council of Directors. The term for Regional Directors shall be three years and there shall be a limit of the Regional Director serving two consecutive terms. Nominations are being accepted for:
Region III – Central, Director
Region VI – Western, Director

Integration and Outreach Groups coordinate the activities of related Integration and Outreach Committees to facilitate cooperative efforts between the various professional areas. An Integration and Outreach Group Director shall lead each Integration and Outreach Group. All voting members shall elect the Integration and Outreach Directors. The Integration and Outreach Director for each group shall be a member of the Integration and Outreach Activities Division (IOD) as well as a delegate to the Council of Directors. The term for Integration and Outreach Group Directors shall be three years and there shall be a limit of the Integration and Outreach Group Director serving two consecutive terms. Nominations are being accepted for:
Young Professionals Group, Director-Elect

Technical Groups coordinate the activities of related technical committees to facilitate cooperative efforts between the various technical disciplines. A Technical Director shall lead each Technical Group. The voting members who belong to that group shall elect the Technical Director for that group. The Technical Director for each group shall be a member of the Technical Activities Division (TAD) as well as a delegate to the Council of Directors. The term for Technical Directors shall be three years and there shall be a limit of the Technical Director serving two consecutive terms. Nominations are being accepted for:
Aerospace Design and Structures Group, Director
Aerospace Sciences Group, Director

To nominate an AIAA member in good standing for the open positions on the AIAA Council of Directors, please submit the nominee's bio and/or CV, history of AIAA activities and/or engagement with other professional societies, and a statement from the nominee of willingness and ability to serve if elected.

Please submit nominations directly to Christopher Horton, AIAA Governance Secretary, chrish@aiaa.org, **no later than 1800 hrs EDT, 17 July 2020**.

Important Announcement: New Editor-in-Chief Sought for the AIAA Journal

AIAA is seeking an outstanding candidate with an international reputation for this position to assume the responsibilities of Editor-in-Chief of the *AIAA Journal* in early 2021.

The Editor-in-Chief is responsible for maintaining and enhancing the journal's quality and reputation as well as establishing a strategic vision for the journal. He or she receives manuscripts, assigns them to Deputy Editors or Associate Editors for review and evaluation, and monitors the performance of the editorial team to ensure that the manuscripts are processed in a fair and timely manner. The Editor-in-Chief works closely with AIAA staff on implementing publications policies and procedures, planning special collections of papers, and scheduling monthly issues. AIAA provides all appropriate resources to support the peer-review process, including a web-based manuscript-submission and tracking system.

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

Complete application requirements and deadline are available at Aerospace Research Central (https://arc.aiaa.org/neweicaiaaj2021).

Nominate Your Peers and Colleagues!

NOW ACCEPTING AWARDS NOMINATIONS

NOMINATION DEADLINE OF 1 JUNE

AIAA-ASC James H. Starnes Jr. Award

NOMINATION DEADLINE OF 1 JULY

PUBLICATION/LITERARY AWARDS

- Children's Literature Award
- Gardner-Lasser Aerospace History Literature Award
- History Manuscript Award
- Pendray Aerospace Literature Award
- Summerfield Book Award

SERVICE AWARDS

- Diversity and Inclusion Award
- Sustained Service Award

TECHNICAL AWARDS

- Aerospace Software Engineering Award
- Ashley Award for Aeroelasticity
- de Florez Award for Flight Simulation
- Information Systems Award
- Mechanics and Control of Flight Award

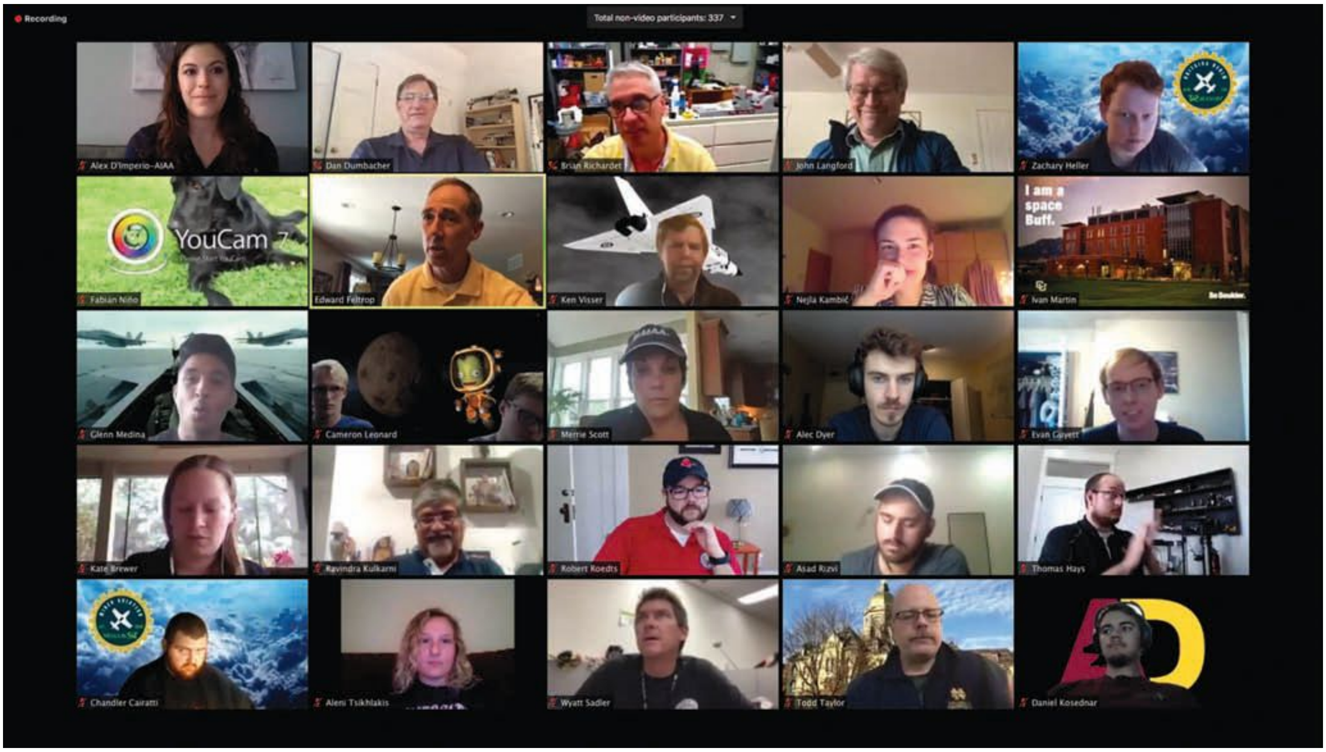
Please submit the nomination form and endorsement letters to **awards@aiaa.org**

For nomination forms or more information about the AIAA Honors and Awards Program, visit **aiaa.org/AwardsNominations**.

AIAA SHAPING THE FUTURE OF AEROSPACE

MAKING AN IMPACT

Design/Build/Fly Continued After Grounding



Each year AIAA invites university students from around the globe to participate in the AIAA/Textron Aviation/Raytheon Missile Systems Design/Build/Fly (DBF) Competition (**aiaa.org/DBF**). DBF is a premier event for student aerospace engineers because it provides a real-world aircraft design test for them by giving them the opportunity to validate their analytic studies. DBF experience is known to give students a resume boost.

This year the 24th annual DBF fly-off in Wichita, KS, was cancelled due to the coronavirus pandemic, but the formal report portion continued.

The 2019–2020 winners are:

First Place ($3,000 and $100 for Best Report Score): University of Southern California

Second Place ($2,000): Georgia Institute of Technology

Third Place ($1,500): University of Nevada, Las Vegas

You can watch footage of many 2019–2020 teams flying their aircraft at AIAA's YouTube channel: www.youtube.com/playlist?list=PLOl-5RDXeYOMBVWHKOu5rz-4TXObH-yu60X.

DBF's success is thanks to the many volunteers from Textron Aviation, Raytheon Missile Systems, and the AIAA sponsoring technical committees: Applied Aerodynamics, Aircraft Design, Flight Test, and Design Engineering. These volunteers collectively set the rules for the contest, publicize the event, gather entries, judge the written reports, and in all other years, organize the fly-off.

University of Southern California (USC)

The 2019-2020 USC AeroDesign Team airplane, SCkyfall, was a foam monoplane that carried 39 passengers and towed a 450-inch banner. The fuselage was made of foam covered with fiberglass, and the nose was reinforced with carbon fiber. The wing consisted of a foam core covered with fiberglass and carbon spar caps, while the tail was made of flat balsa plates. The landing gear was a carbon bow gear placed in a tail-dragger configuration.

The USC team said they "gained valuable experience measuring in-flight banner drag to define a Reynolds Number design range and determine the banner geometry that minimized drag. The 2019-2020 year was also the team's first experience in over a decade designing an airplane that weighed more than 20 pounds when fully loaded, so the team learned build techniques that

TOP: The USC team leadership at their Critical Design Review.

BOTTOM: USC's first prototype at a test flight.

allowed the aircraft to withstand flight loads associated with airplanes of this weight class."

USC Faculty Advisors
Charles Radovich
Wyatt Sadler

USC Team Members
Ara Mahseredjian
Michael Tawata
Chentao Yu
Neeraj Utgikar
Michelle Karpishin
Drew Hudock
Ben Boggs
Lawrence Goo
Jackson Markow
Muqun Hu
Jack Ahrens
Diana Salcedo-Pierce
Randi Arteaga

Georgia Tech team.

Georgia Institute of Technology

The Georgia Tech team said, "this year's DBF competition was very challenging, with a complex scoring function and unique payloads. It was a steep learning curve for all of us as we worked to balance competing requirements, CAD complex geometries, and build on a tight schedule. We also tried to implement some new building techniques to improve our aircraft's performance and learned from our mistakes in the process. Even though we couldn't go to the fly-off, the work we put into developing, building, and testing an aircraft for competition has been an incredible experience that we're all proud of."

Georgia Tech flight test with banner.

Flight test.

UNLV success.

Georgia Tech Faculty Advisor
Carl Johnson

Georgia Tech Team Members
Daniel Sagan
Harshini Sivakumar
Antoine Paletta
Thomas Walker
Arunachalam Palaniappan
Ethan Das
Yuchen Xie
Xiaoyu Huang
Anderson Page
Pranav Krishnamurthy
Scott Nealon
Parth Kumar
Tristan Huang

Tweaking the aircraft.

UNLV's Bullitt Bill ready to fly.

University of Nevada, Las Vegas (UNLV)

The UNLV AIAA team comprised a handful of students with a passion for aviation, even though UNLV doesn't have an aerospace engineering program.

UNLV team members said, "We combined our knowledge of aircraft design, engineering software, manufacturing techniques, and love for aviation in order to conceptualize and design our aircraft. Throughout our work on Bullitt Bill, we developed our skills and expertise in everything from XFLR15 to carbon fiber layup techniques. We are proud to come from a small and close-knit organization that has, in only two years, managed to receive third place on a very reputable competition. Spending endless hours together in our machine shop brought us together as a group and made every single one of us a better engineer!"

UNLV Faculty Advisor
William Culbreth

UNLV Team Members
Sophia Leon
Jet Baroudi
Emma Chao
Spencer Buyse
Jessalynn O'Brien
Kevin Rodriguez
Angel Barajas
Karsten Cartright
Anthony Costanzo
Brandon Avendano
Victor Quintanilla
Devin Krystek
David Quintanilla
Yamileth Mejia
Cooper Madrazo

For more information about how to get involved with AIAA and make an impact on the next generation of aerospace engineers, please visit www.aiaa.org/get-involved or contact Merrie Scott, merries@aiaa.org.

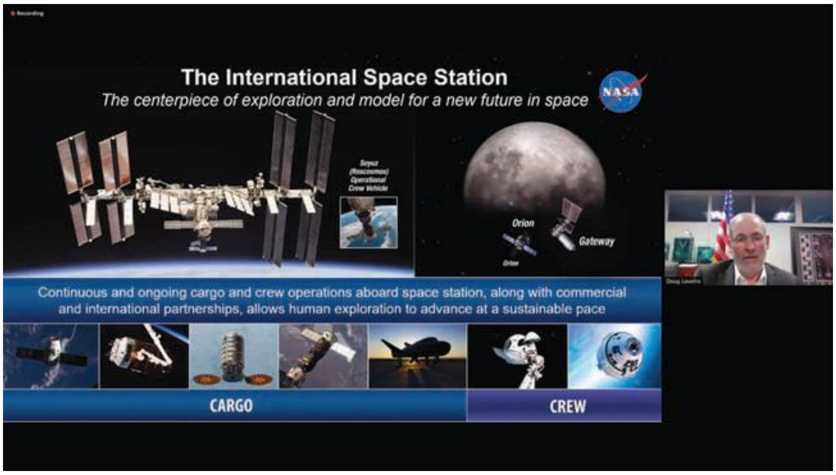
HEADQUARTERS News

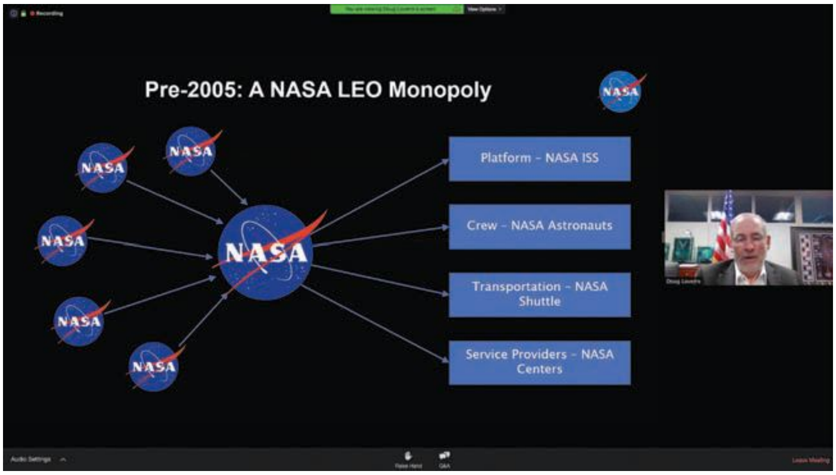
AIAA Hosts Webinar with Doug Loverro

On 20 April, AIAA hosted a webinar on Commercial Development in Low Earth Orbit with Doug Loverro, then NASA Associate Administrator of the Human Exploration and Operations Mission Directorate. Over 500 viewers watched the session live. Viewers included top industry executives, young professionals, students and academics, retirees, international members, officials from ESA and NASA, and congressional staffers.

AIAA members can access the video recording of the webinar by going to **aiaa.org/events-learning/event/2020/04/20/default-calendar/briefing-commercial-development-in-low-earth-orbit-(member-exclusive-webinar)**.

AIAA will be hosting additional webinars on topics of interest beginning with a briefing by NASA Associate Administrator Steve Jurczyk on 1 June, 1300–1400 hrs EDT (**https://www.aiaa.org/events-learning/event/2020/06/01/default-calendar/briefing-nasa's-steve-jurczyk-(free-webinar)**).





AIAA and Royal Aeronautical Society Sign MOU to Join Forces on Future Aerospace Outreach

AIAA and the Royal Aeronautical Society (RAeS) have entered into a Memorandum of Understanding (MOU) to enable the two preeminent professional aerospace societies to collaborate on future endeavors.

"AIAA looks forward to collaborating with the Royal Aeronautical Society to unite our strengths in helping shape the aerospace community and giving meaningful benefits to our members," said Dan Dumbacher, AIAA executive director. "As virtual events become the norm, we can more easily take a collective international approach to inform and engage the aerospace community. By doing so, we hope to capture the imaginations of students, whom the aerospace community needs if we are to continue exploring and making new discoveries. Working together, AIAA and RAeS plan to show the creativity, dedication and science that drives aerospace professionals and open up the possibilities of the future of aerospace."

Professor Jonathan Cooper, president of the RAeS commented, "As the aerospace sector rises to tackle the challenging environment we are all operating in, the Royal Aeronautical Society looks forward to joining forces with the American Institute of Aeronautics and Astronautics to support the workforce, apprentices and students through this period, and also after we have overcome the pandemic.

There are many exciting opportunities ahead for the tomorrow's aerospace professional as we embrace the future of flight and strive to reach new frontiers whilst also tackling the hard questions on climate change and sustainability."

AIAA and RAeS plan to cooperate in the following areas:

- Promoting learned activities such as lectures, conferences, and other activities of mutual interest;
- Recognizing our members with joint honors and awards initiatives;
- Other areas of interest that may arise.

Space Policy Pod

Given the current real-world challenges confronting all of us, AIAA has joined The MITRE Corporation, Space Foundation, and the U.S. Chamber of Commerce to produce this podcast series to examine events and ideas affecting the space sector. Each episode will feature an open and candid discussion with a prominent policy leader. The episodes serve as an enlightening discussion on the relevant topics of the day with insights from key policymakers in the field.

The first podcast episode with Scott Pace, Deputy Assistant to the President and Executive Secretary of the National Space Council, was released on 6 May. Episode 2 with Matt Scholl from the National Institute of Standards and Technology was released on 20 May. Episodes can be found at aiaa.org/events-learning/podcasts.

Aerospace Career Pathways: AIAA Student Webinar Series

Take advantage of this free opportunity for AIAA students to hear from successful professionals on four different tracks in the aerospace industry: public service, academia, professional engineering, and entrepreneurship. Discover firsthand how these individuals developed their professional skills and overcame career challenges, and hear insights that will help students during their student-to-professional transition. Explore more about the topics and speakers at aiaa.org/events-learning/aiaa-webinars.

SECTION News

L to R: Elizabeth Balga, section chair; Leslie Lake, Business Development for RS&H, Inc.; Congressman Bill Posey, U.S. Representative for Florida's 8th Congressional District; and Jim Kuzma, Senior Vice President and General Manager for Space Florida.

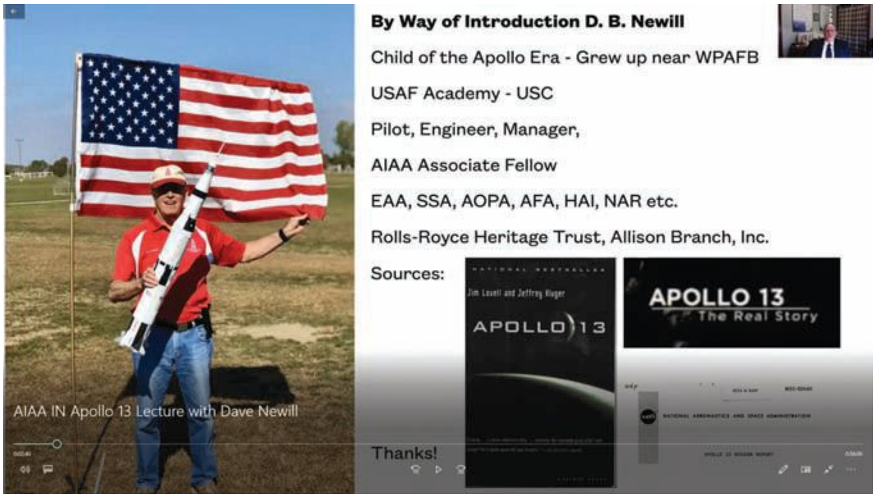
Cape Canaveral Section Hosts Panel on Space Policy and Economic Development

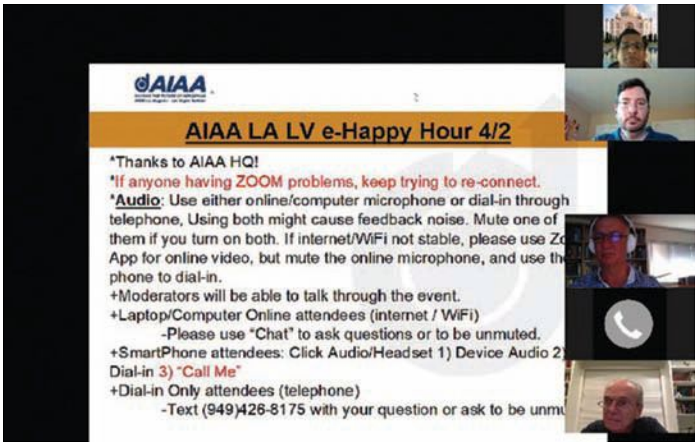
On 19 February the AIAA Cape Canaveral Section hosted a moderated panel discussion on "Space Policy and Economic Development." Congressman Bill Posey discussed his amendment to the SPACE Act (H.R. 2262) that streamlines regulatory processes, encourages cooperation between government agencies and eliminates red tape of the commercial space sector.

The panel also explored economic developments in commercial space activity and manufacturing in zero G, including 3D printing of human organs and pharmaceuticals, before discussing the mobile launcher for moon missions. The legacy Mobile Launch Platforms that carried the Saturn-V are being modified to support the new Space Launch System (SLS) Expendable Launch Vehicles that will carry astronauts back to the moon and on to Mars.

Indiana Section Recognizes 50th Anniversary of Apollo 13

In mid-April the AIAA Indiana Section hosted a virtual talk by Dave Newill in honor of the 50th anniversary of Apollo 13. Newill, an AIAA Associate Fellow and retired Rolls-Royce executive, discussed how 50 years ago, on 14 April, Apollo 13 was explosively damaged, short of oxygen and electricity and heading behind the moon. The lecture celebrated the safe return of the Apollo 13 astronauts and examined what had to happen to allow them to safely return to Earth.





Attendees enjoying the conversations while reviewing the logistics reminder. Images on the right: top: Dr. Chandrashekhar Sonwane, AIAA LA-LV Section Chair; middle with white headset: Dr. Daniel P. Raymer, AIAA Fellow; bottom: Jerry Lockenour).

Maintaining Connections with an AIAA Virtual Happy Hour

By Brett Cornick, AIAA LA-LV Council Member

On 2 April, the AIAA Los Angeles-Las Vegas (LA-LV) Section hosted an electronic happy hour geared specifically toward young professionals as an opportunity for them to meet and network during this time of social distancing. Nearly 30 active members ranging from college students to seasoned professionals gathered virtually online to share stories, industry insights, job search tips, and words of motivation for any young professionals looking for opportunities and advice in this troubling time. The event lasted 90 minutes and was the first of what is likely to be a series of similar events hosted over the next few months. This event provided a unique opportunity for all members to speak and be heard in a low-stakes, friendly environment.

I was fortunate enough to be given the task of moderating the happy hour, sponsored by the AIAA LA-LV Young Professionals, despite relatively minimal involvement in planning and organizing other AIAA events. All it took was a simple email from me offering my time as a volunteer and before I knew it, I was put on the job! AIAA is always looking for more young professionals to get involved, so if you find yourself with too much time on your hands during the stay-at-home orders, volunteering for these e-events is a great way to network and stay productive!

Obituaries

AIAA Fellow Passman Died in April

Richard Passman, an aeronautical engineer whose wide-ranging career took him through the early stages of supersonic flight, spy satellites and intercontinental ballistic missiles, died on 1 April, from complications from COVID-19. He was 94.

Mr. Passman earned a bachelor of science degree in aeronautical engineering in 1944, a bachelor's degree in mathematics in 1946, and a master's in aeronautical engineering in 1947, all from the University of Michigan. After the start of World War II, he joined the Navy Flight Training Program from the University of Michigan.

Joining Bell Aircraft, he was involved in the design of the Bell X-1 and served as chief aerodynamicist on the X-2. He also was aircraft designer for Bell's X-16, a spy plane, but the government chose Lockheed's U-2.

Moving to General Electric, he concentrated on spacecraft. He was a manager in a part of the company responsible for creating systems that allowed objects sent plunging through the atmosphere to withstand the blazing heat of re-entry. This included the Corona, the first spy satellite, which would high-resolution photographs and ejected the film in a heat-shielding "bucket." The container re-entered the atmosphere, deployed a parachute and was snagged out of the air by military aircraft. G.E. was responsible for the bucket.

Mr. Passman also helped lead efforts to create heat shielding technology for intercontinental ballistic missiles and multiple-warhead missiles. He continued to work on projects for the space program as G.E.'s general manager for space activities, which involved systems for Mercury, Gemini and Apollo, including the SNAP-27 power systems still on the moon, and he worked on the development of the Manned Orbiting Laboratory before it was cancelled. He also spent time working at the Department of Energy and also at Grumman on re-designs of the International Space Station.

In retirement, Mr. Passman volunteered at the Smithsonian National Air and Space Museum, and he and John Anderson co-wrote *X-15: The World's Fastest Rocket Plane and the Pilots Who Ushered in the Space Age*, published in 2014 by the Smithsonian.

Mr. Passman was a lifelong member of AIAA, having joined as a teenager (he was the youngest member at that time). He also served as chair of the AIAA Philadelphia Section in the early 1970s.

AIAA Fellow Singer Died in April

Dr. S. Fred Singer passed away on 6 April. He was 95.

Dr. Singer, escaped from Austria after the Nazi invasion when he was sent to England as part of the "Kindertransport" program. In the 1940s, he immigrated to the United States, serving in the Navy during World War II. In 1943, he received a bachelor's degree in electrical engineering from Ohio State University and then master's and doctoral degrees in physics from Princeton University in 1944 and 1948, respectively.

Dr. Singer was a consultant during the start-up of the U.S. space program in the 1950s and later, while working for what is now NOAA, he worked on early efforts to use satellites in weather forecasting.

He taught at several universities, first as a professor at the University of

Maryland in the 1950s, before moving to the University of Miami in 1964, where he became the first dean of a school of environmental and planetary studies. He held high-ranking positions at the Interior Department and the Environmental Protection Agency before joining the faculty of the University of Virginia in 1971. In the late 1980s, Dr. Singer was chief scientist at the U.S. Transportation Department and in the 1990s a research professor at George Mason University.

Dr. Singer oversaw some of the first experiments with high-altitude rockets and satellites, and he wrote many research papers and contributed articles to the popular press.

In 1990, Dr. Singer founded the Science and Environmental Policy Project, and in 2007, he helped launch the Non-governmental International Panel on Climate Change (NIPCC). He believed that government regulations were wrong and expensive. He focused his attention mostly on climate change, and he became known as a climate change denier.

AIAA Associate Fellow Rozycki Died in April

Richard C. (Dick) Rozycki died on 15 April, at the age of 87, from complications from COVID-19.

He was a 1955 graduate of the University of Minnesota with a B.S. in Aeronautical Engineering. In 1963, he earned a Master of Science degree in Aeronautical Engineering from the University of Colorado.

Mr. Rozycki started out as an aeronautical engineer with Lockheed in 1955. He began working for Martin Marietta Aerospace in Littleton, CO, in 1960. Mr. Rozycki had a two-year assignment in New Orleans in the late 1970s, where he supported development of the external fuel tank for the first flights of the Space Shuttle. He retired from Martin Marietta (by then Lockheed Martin) in 1996.

Mr. Rozycki obtained his private pilot's license when he was at the University of Minnesota, and he flew small planes regularly, often showing off his aerobatic skills and taking passengers for a loop, a barrel roll, or a hammerhead spin.

AIAA Honorary Fellow Beggs Died in April

James M. Beggs, who served as the NASA administrator in the early 1980s, died on 23 April. He was 94.

After a year at Southern Methodist University, Mr. Beggs entered the U.S. Naval Academy, graduating in 1947 as part of an accelerated program. He served in the Navy until 1954. He received an MBA from Harvard University soon after, before going to work for Westinghouse until 1968, when he became NASA's chief of research in Washington. He worked at the Transportation Department from 1969 to 1973.

In 1974, Mr. Beggs became an executive vice president of General Dynamics, managing defense and aerospace projects. In 1981, he became NASA's sixth administrator, serving until after the *Challenger* disaster on 28 January 1986. Under Mr. Beggs's leadership, NASA grew to an annual budget of nearly $8 billion, 20,000 employees, and had more than 20 successful space shuttle missions. He worked to reestablish NASA's standing with the space shuttle program and a new space station, which NASA was directed to build in 1984 by President Ronald Reagan.

He resigned as administrator soon after the *Challenger* explosion. He worked for various aeronautical companies, served on corporate boards, and worked as a consultant well into his 80s. Mr. Beggs joined AIAA in 1968 and became an Honorary Fellow in 1997.

AIAA Associate Fellow Boyer Died in April

Donald W. Boyer, Calspan retired aerodynamicist, passed away at the age of 91 on 30 April.

Mr. Boyer grew up in Australia, where he completed his undergraduate studies at the University of Melbourne (B.Sc., Physics, 1953), and then received his Ph.D. in Aerophysics and Aerospace Engineering in 1959 from the University of Toronto. He worked at the Cornell Aeronautical Laboratory right out of college. In 1970, the Cornell Lab became Calspan, and he retired from Calspan in 1995.

During his three-and-a-half decades of research, Dr. Boyer conducted experiments in high-energy, chemically-active flows such as those associated with shock tunnels, rocket nozzles and exhaust plumes, and hypersonic flight. His work combined fluid dynamics and high-temperature physics with creative experiments. Dr. Boyer made important contributions to the U.S. space surveillance program, providing key data (such as band strengths and reaction rates) that characterized the thermochemistry and associated radiation signatures of high altitude rocket exhaust plumes.

Throughout the Apollo program, his research contributed important understanding to the problem of communications blackout associated with space vehicle re-entry. Later during the Space Shuttle program, he performed laboratory measurements that confirmed and characterized the role of exoatmospheric O-atom collisional excitation of outgassing H2O as the explanation of observed glow from the Space Shuttle and other orbiting space vehicles.

The development programs of many U.S. space vehicle systems benefited from Dr. Boyer's contributions to the application of the gaseous-equivalent propellant technique for the duplication (or simulation) of rocket solid propellants. This technique was particularly applicable to short-duration testing capabilities at the Calspan shock tunnels for investigating base heating effects associated with the Space Shuttle vehicle in boost-phase flight, as well as for studies of exoatmospheric plume signatures, and plume effects on deployed payloads from post-boost vehicles (Poseidon/Trident systems).

Dr. Boyer wrote over 50 technical reports and papers, many of the latter published at AIAA conferences and in AIAA journals. In the late 1980s he had the distinct honor of presenting the Gordon N. Patterson Lecture at the University of Toronto. In 2017 he was inducted into the Niagara Frontier Aviation and Space Hall of Fame. He was an active member of the AIAA Niagara Frontier Section and a member of the AIAA Plasmadynamics and Lasers Technical Committee.

1920

June 4 The U.S. Army Air Service is declared the permanent combat air arm of the U.S. Army when Congress passes and President Woodrow Wilson signs the United States Army Reorganization Act. The Army Air Service is formally separated from the Signal Corps in the first step toward eventual military aviation independence. The Army Air Service was established on May 24, 1918, but it was a temporary arrangement. Maurer Maurer, ed. **Air Force Combat Units of World War II**, p. 4.

During June Imperial Japanese Navy Lt. Torao Kuwabara becomes the first person to fly an airplane off a deck installed on a ship when he pilots his Sopwith Pup from the seaplane carrier Wakamiya. On Sept. 5, 1914, the Wakamiya had conducted the first ship-launched aerial attack, when its Farman seaplanes took off from the water and attacked German ships and installations near Tsingtao, China, at the outbreak of World War I. In April 1920, the ship was modified with a deck to launch conventional aircraft, such as the Sopwith Pup. Rene Francillon, **Japanese Aircraft of the Pacific War**, p. 38.

1945

June 2 Robert Goddard receives an honorary doctorate degree from Clark University, where he had earned his doctorate in physics in 1911. He is cited in the award as an "outstanding authority on the development and use of the modern rocket," and an "indefatigable investigator of methods of improvement of rocket propulsion." E.C. Goddard and G. Edward Pendray, **The Papers of Robert H. Goddard**, pp. 1,604-1,605.

June 14 Britain's Avro Tudor I airliner makes its first flight. Based on the Avro Lincoln bomber and fitted with a pressurized fuselage, the Tudor is powered by four Rolls-Royce Merlin 100 motors that provide the Tudor 1 with a maximum range of about 7,000 kilometers at an average speed of 370 kph. The plane can carry a dozen passengers when outfitted with bunks for overnight sleeper flights or 24 passengers with upright seating. Several accidents will mar the Tudor series record. **The Aeroplane**, June 22, 1945, p. 702.

June 22 The prototype of the Vickers-Armstrong Viking makes its first test flight. Derived from the Vickers Wellington medium bomber, it will become Britain's replacement for the Douglas DC-3 and remain in service until 1972 after 163 are built. One Viking will be fitted with two Rolls-Royce Nene turbojets in April 1948 and become one of the first jet-powered airliners, although it does not enter commercial service. **The Aeroplane**, July 6, 1945, p. 3.

June 25 Construction begins on the White Sands Proving Ground in New Mexico, which subsequently sees the launching of the first large-scale liquid-fuel rockets in the U.S., captured German V-2 rockets, as well as other important early rockets. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 50.

June 25 The United States' first all-cargo commercial airline, the National Skyway Freight Corp., is formed by Robert Prescott, a member of the American Volunteer Group, popularly known as the Flying Tigers, that flew for Nationalist China against the Japanese during World War II. In 1946 it will be renamed the Flying Tiger Line to honor its founder. It will merge into Federal Express in 1989. Camille Allaz, **History of Air Cargo and Airmail from the 18th Century**, pp. 178–181.

June 27 The Pilotless Aircraft Research Station is established at Wallops Island, Virginia, for the improved development of both jet- and rocket-powered craft. The facility is part of the National Advisory Committee for Aeronautics' Langley Memorial Aeronautical Lab, which will be renamed NASA's Langley Research Center. Many of the small rocket vehicles test aerodynamic shapes under high-speed conditions and are fitted with sensors that transmit pressure readings and other data to ground-based receivers. M.D. Keller, **Fifty Years of Flight Research: A Chronology of the Langley Research Center**, p. 57.

June 30 The 509th Composite Group, U.S. Army Air Forces, moves from Westover Field, Utah, to the Pacific island of Tinian to begin combat flight training in preparation for the first atomic bomb attack on Japan. K.C. Carter and R. Mueller, compilers, **The Army Air Forces in World War II**, p. 669.

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1970

June 1 The National Science Foundation announces that high-altitude photos taken of the planet Uranus by a 9-centimeter telescope on the Stratoscope II balloon during March 26-27 might reveal whether Uranus has a cloud cover. Much later, in 1986, the United States' Voyager 2 will find and more closely examine numerous cloud features around the planet. **Washington Star**, June 2, 1970, p. A10.

June 2-19 The Soviet Union's Soyuz 9, carrying cosmonauts Andryan Nikolayev and Vitaly Sevastyanov, is launched from the Baikonur Cosmodrome into a low-Earth 249-kilometer (apogee) by 236-km (perigee) orbit and conducts an extensive program of scientific and technical research. This research includes medical and biological studies; studies of Earth's geography, resources and atmosphere; and meteorite observations. The mission will conclude when the spacecraft lands 76 km west of Karaganda, Kazakhstan, after orbiting for 17 days, 16 hours and 59 minutes, setting a record for crewed space flight. **New York Times**, June 3, 1970, p. 18; **Aviation Week**, June 29, 1970, pp. 21-22.

June 2 The Northrop M2F3 Lifting Body is flown for the first time as part of a NASA program to compile flight data toward the design of a space shuttle. The Lifting Body launches at 13,716 meters altitude from a B-52 aircraft and attains a speed of Mach 0.071 during its descent at NASA's Ames Flight Research Center in Silicon Valley. The M2F3 is a modified, rebuilt version of the M2F2 that was damaged in a landing accident on May 10, 1967. **Aviation Week**, June 8, 1970, p. 24.

June 3 The Edward H. White II Memorial Museum is dedicated at Brooks Air Force Base, Texas, in honor of astronaut White, who died with his two crewmates on Jan. 27, 1967, in the Apollo 1 launchpad fire. The museum is near White's hometown of San Antonio. NASA, **Astronautics and Aeronautics, 1970**, p. 192.

June 6 Alaska Airways inaugurates its "Gold Samovar" flight service between Anchorage, Alaska, and central Soviet Union. This marks the first commercial air passenger route that had been negotiated by a private airline company with the Soviet Union. **Washington Post**, June 16, 1970, p. C-2.

June 7 Astronaut Charles Conrad Jr., on behalf of the Apollo 12 crew, receives a special Emmy Award from the National Academy of Television Arts and Sciences in New York for TV photography during the Apollo 12 lunar landing. **Washington Star**, June 8, 1970, p. B-9.

June 9 Sikorsky pilot James Wright and co-pilot U.S. Marine Corps Col. Henry Hart, flying a Marine Corps Sikorsky CH-53D Sea Stallion heavy-lift helicopter, establish a New York-to-Washington, D.C., record for helicopters with a speed of 251.74 kph in an elapsed time of 1 hour, 18 minutes and 41 seconds. **United States Naval Aviation, 1910-1970**, p. 281.

June 12 All three stages of the European Launcher Development Organization's Europa F-9 test vehicle operate in a test mission conducted from Woomera, Australia, although the vehicle fails to orbit a test satellite because the payload fairing jettison system does not work. This is the last of the Europa 1 development series tests. **Aviation Week**, June 22, 1970, p. 257.

June 19 The U.S. Defense Department launches its third early warning satellite, designed to detect an enemy ballistic missile attack and provide up to 30 minutes of warning. Designated the 1970-46A, the satellite is boosted from the Air Force Test Station at Cape Canaveral, Florida, by an Atlas-Agena-D. **Aviation Week**, June 29, 1970, p. 18; NASA, **Astronautics and Aeronautics, 1970**, pp. 209, 426.

June 24 Roscoe Turner, winner of the Harmon Trophy in 1932 and of the Thompson Trophy air races in 1934, 1938 and 1939, dies in Indianapolis at age 74. Turner was recognized for his flamboyant style and his pet Gilmore the Lion who flew with him on some flights. Turner later was chairman of the board of the Roscoe Turner Aeronautical Corp. flight school. **Washington Star**, June 24, 1970, p. B-5.

1995

June 2 U.S. Air Force Capt. Scott O'Grady is shot down by a Serbian SA-6 surface-to-air missile while patrolling over Bosnia and Herzegovina in an F-16 Fighting Falcon. O'Grady ejects and will evade capture for six days until he is rescued on June 8 by U.S. Marines. O'Grady, Scott, and Coplon, Jeff. **Return with Honor**. 1998.

June 10-18 The X-31 Enhanced Fighter Maneuverability Demonstrator becomes the first X-plane to fly at a major public event when it flies at the 1995 Paris Air Show. During the jet's eight flights, pilots Fred Knox of Rockwell International and Lt. Col. Quirin Kim of the German Luftwaffe wow the crowds with the X-31's precise control at high angles of attack. The only other X-31 was destroyed in a crash four months earlier at its Edwards Air Force Base, California, testing site. The X-31 aircraft were designed and built by Rockwell International (now Boeing) and Messerschmitt-Bölkow-Blohm, which became the European Aeronautic Defense and Space Co., or EADS, and is now Airbus Defense and Space. Contributed by **Michael S. Francis**.

SYLVIE DELAHUNT, 28

Supervisor, Future Weapon Concepts and Algorithms Section at Johns Hopkins Applied Physics Laboratory

Since she had a natural talent for math and science, Sylvie DeLaHunt's elementary and middle school teachers in suburban Washington, D.C., encouraged her to become an engineer. DeLaHunt warmed to the idea of a career like that of her father, who oversees attitude determination and control systems for spacecraft at the U.S. Naval Research Laboratory. She liked the idea of proving herself in a male-dominated field. DeLaHunt earned bachelor's and master's degrees in aerospace engineering at the University of Maryland, College Park, where she was a founding officer of the Women in Aeronautics and Astronautics student organization. From college, DeLaHunt went directly to the Johns Hopkins Applied Physics Laboratory to design subsystems and algorithms that control the motion of aerospace vehicles.

Addressing missile threats ▶ I perform guidance, navigation and control trade studies, trajectory optimization, and modeling and simulation to help program managers understand the capabilities of defensive weapons and how design decisions may influence performance. The air and missile defense work performed by APL with our government and industry peers is critical for protecting our nation and allied forces from air and missile attack. We develop defensive weapons to counter or defeat new and emerging threats posed by long-range ballistic and cruise missiles. Additionally, we seek to counter advanced future challenges posed by hypersonic threats, coordinated raids of missiles, autonomous vehicles and nonkinetic kill mechanisms.

Diversity and inclusion ▶ In addition to my day job, I promote diversity and inclusion at APL and in the broader aerospace community. At APL, I am president of our Society of Women Engineers affinity group. Through the AIAA Diversity and Inclusion Working Group, I collaborate with other AIAA members to enhance the representation of women and people of different races and ethnicities in the professional society. Additionally, I advocate for adapting collegiate engineering programs to promote the inclusion and success of all students through presentations at local universities and women in STEM conferences.

Space in 2050 ▶ To improve recruitment and retention of a diverse engineering student body, the aerospace community must evaluate whether elements we often consider to be "inherent" to traditional engineering programs are truly necessary. Implicit biases, alienating cultures and unclear grading policies reinforce negative stereotypes and continue to discourage today's female and minority students. Aerospace academic programs must tackle the institutional barriers to success and send an inclusive message about who makes a good engineering student. At the professional level, I expect 2050 will see aerospace companies focused not only on bringing together teams with diverse backgrounds, experiences and thought, but also on empowering members to bring their whole selves to the profession. Inclusion enables us to embrace the creative tension that stems from diverse teams, maximizing creativity and innovation. ★

BY DEBRA WERNER | werner.debra@gmail.com