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AEROSPACE AMERICA

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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, Moriba Jah,
Robert van der Linden,
Sarah Wells, Frank H. Winter

Basil Hassan **AIAA PRESIDENT**
Daniel L. Dumbacher **PUBLISHER**
Rodger Williams **DEPUTY PUBLISHER**

ADVERTISING
advertising@aiaa.org

ART DIRECTION AND DESIGN
THOR Design Studio | thor.design

MANUFACTURING AND DISTRIBUTION
Association Vision | associationvision.com

LETTERS
letters@aerospaceamerica.org

CORRESPONDENCE
Ben Iannotta, beni@aiaa.org

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SHAPING THE FUTURE OF AEROSPACE

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Keith Button

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

As our staff reporter, Cat covers news for our website and regularly contributes to the magazine.
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Moriba Jah

Before becoming an associate professor at the University of Texas at Austin, Moriba helped navigate the Mars Odyssey spacecraft and the Mars Reconnaissance Orbiter from NASA's Jet Propulsion Lab and worked on space situational awareness issues with the U.S. Air Force Research Laboratory.
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Sarah Wells

Sarah is a science and technology journalist based in Boston interested in how innovation and research intersect with our daily lives. She has written for national publications and covers innovation news at Inverse.
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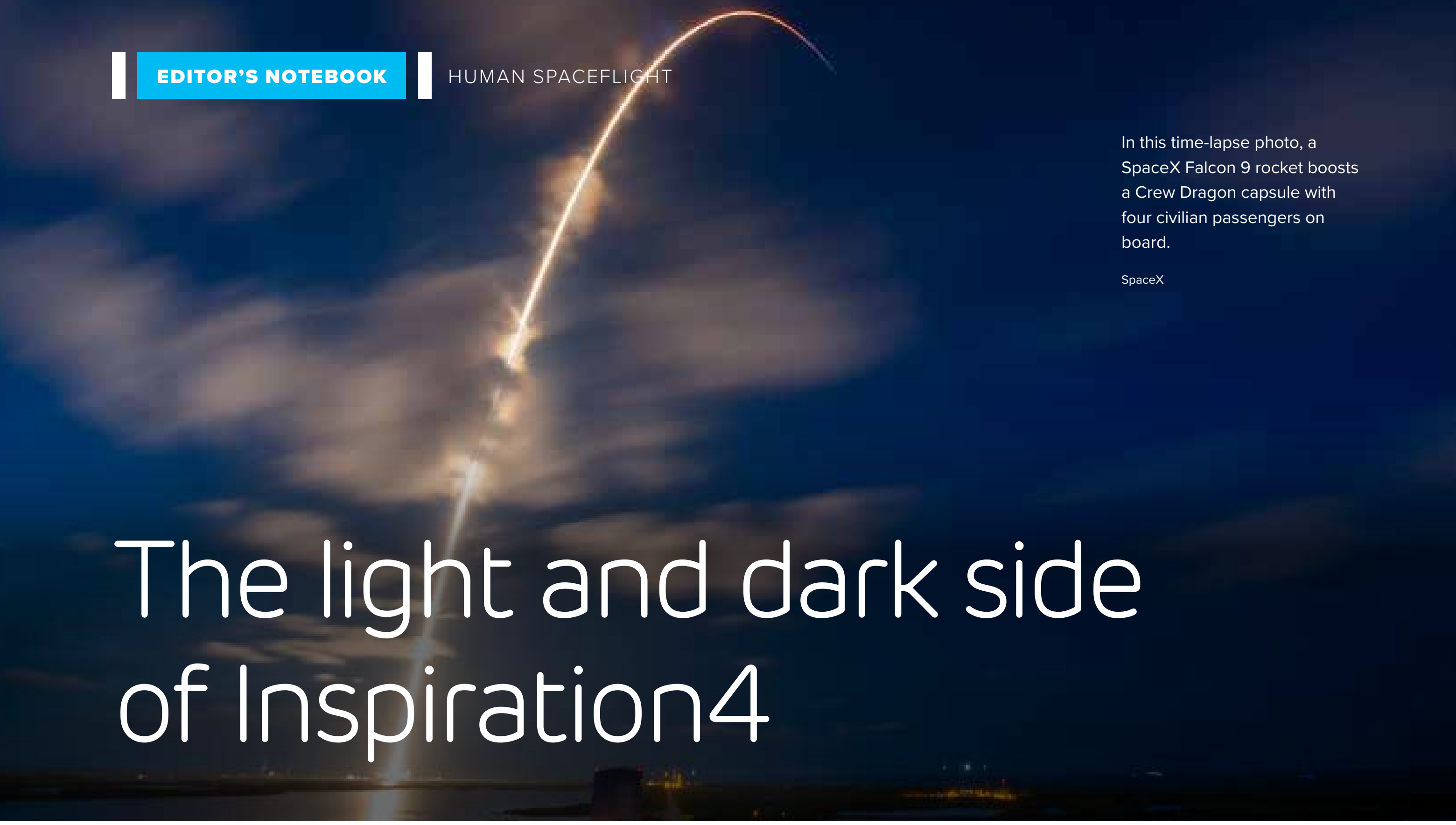
DEPARTMENTS



In this time-lapse photo, a SpaceX Falcon 9 rocket boosts a Crew Dragon capsule with four civilian passengers on board.

SpaceX

The light and dark side of Inspiration4

The Inspiration4 mission was inspiring in one sense: Humanity may indeed be on the cusp of going to space in significant numbers. As the science experiments and charity element of the flight suggest, there might even be a well of citizens out there who want to go to space for more than the view of Earth or to say they were among the first. We could be on the verge of becoming an extraterrestrial society, and that's inspiring.

I also see reason for concern, though. This mission by SpaceX and those by Virgin Galactic and Blue Origin were tightly controlled, insular affairs. The live feeds, the televised after-parties, the softball coverage — they do not feel satisfying. I'm old enough to remember the latter years of the Apollo program, and how the adults around me reacted to Walter Cronkite. He and the news gatherers supporting him had a knack for honoring the achievements of the space pioneers while still covering them with a newsperson's eyes. History tells us that when Cronkite took off his glasses and went speechless after the Eagle landed, his silence said volumes.

The billionaires of spaceflight are probably confident they have the right communications strategy for the times: Go directly to the audience with carefully orchestrated live feeds and tweets like "All is well," or "Definitely upgraded toilets." Then let these tidbits bounce around the echo chamber.

This closed approach will work for a while, but it's uninspiring for someone who's curious about technology and wonders where humanity is headed. Why is that a problem? Because those are the very people who must drive this market forward. The free market will need to correct itself toward more transparency if commercial spaceflight to become more than a novelty. Wise companies will be on the right side of that correction when it comes. A new tier of consumers will demand trustworthy information from trusted sources about such things as safety and the quality of the experience.

Something like this transformation began in the U.S. air transportation industry after the federal government lifted controls over air fares and routes in 1978. Deregulation was applauded by scholars and business executives, but consumers soon grew frustrated at cancellations and overbookings with no warning: "An enemy of a competitive free market is lack of information or inaccurate information," said then Sen. Frank Lautenberg, D-N.J., in 1987, as he advocated consumer protections for air travelers.

A similar reckoning will come for the spaceflight industry, and when it does, that will be good news. The market will at last be real, and it will be led by knowledgeable consumers. ★

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

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Assessing the Path Ahead

To move forward after a turbulent year, AIAA asked our members and the aerospace community at large to gauge the overall sentiment and outlook on the industry, as well as to identify challenges and opportunities for us all. We believe it's an appropriate time to pause and reflect on the past 18 months or so, following the impacts of the COVID-19 pandemic on our industry. We conducted a survey earlier this year to gain the perspectives of those who are driving the profession forward. The recently released "2021 AIAA State of the Industry Report: The Health and Future Outlook of the Aerospace Industry" covers the overall industry outlook, promising and challenged industry sectors, the impact of COVID-19, where policymakers should focus, and how employers are demonstrating a commitment to diversity, equity, and inclusion (DEI).

The report affirms the AIAA Key Issues and provides new insights that will help us address our community's immediate needs and priorities. We are pleased to provide the report exclusively to AIAA members for download at aiaa.org/stateofindustry as a valuable membership benefit. We've also made the Executive Summary free for everyone to access as an industry resource.

The report forecasts a number of exciting technology developments that will be transformational to the industry. While all new technologies come with challenges, four have opportunities that far outweigh these challenges: advanced or additive manufacturing, artificial intelligence (AI)/machine learning, space exploration, and autonomous aircraft. We will use the findings in the report to help us make progress at the pace required to accelerate innovation in our three domains—Aeronautics, Aerospace R&D, and Space. The AIAA Domain approach is helping us lead the aerospace industry in addressing the future challenges across the traditional elements of the industry and embracing these new technology sectors.

Aeronautics Domain

Supersonic and hypersonic flight are viewed with a mixture of optimism and pessimism. On the one hand, professionals see it in the context of advancements and building on a strong knowledge foundation, where both the past experience of the Concorde and new learning from hypersonic weapons development can come into play. Challenges in this area center on perceived technological hurdles and inadequate funding and market support, at least as this time. There are concerns that the technology will not be able to meet economic and ecologic constraints, as well as be vulnerable to cyberattack.

Addressing sustainability and reaching carbon neutrality by 2050 was viewed in the report as extremely or very important to the health and well-being of the aerospace industry by all audience segments. Nearly 50% of respondents agreed that policies are needed to drive innovation and technology development supporting the pursuit of sustainability in aeronautics.

Aerospace R&D Domain

Advanced manufacturing is seen as transformational to current production practices for the aerospace industry and beyond. This view aligns with AIAA's focus on R&D investment, with an emphasis on advanced manufacturing and AI/machine learning to stay on the cutting edge. Excitement about advanced manufacturing is not only driven by the possibilities of new products or faster production cycles – respondents are enthusiastic because of what advanced manufacturing can mean for space exploration and the ability to expand the space economy.

AI/machine learning touches all aspects of society, as well as all aspects of aerospace, and supports the realization of other emerging technologies and applications, including autonomous vehicles. Artificial intelligence expands the human capacity to achieve.

Space Domain

The report states that the space sector needs strong support for developing the technologies and operations for humanity's return to the moon for the long term, and continuing exploration of the solar system and beyond. Advanced manufacturing will be foundational. Space exploration and the development of the space economy also ties into the excitement for autonomous aircraft. AIAA believes autonomy will drive new missions and capabilities otherwise unimaginable, as well as improve performance and lower cost and/or risk for aerospace systems and their missions.

Additional Findings

The report includes other top-line findings:

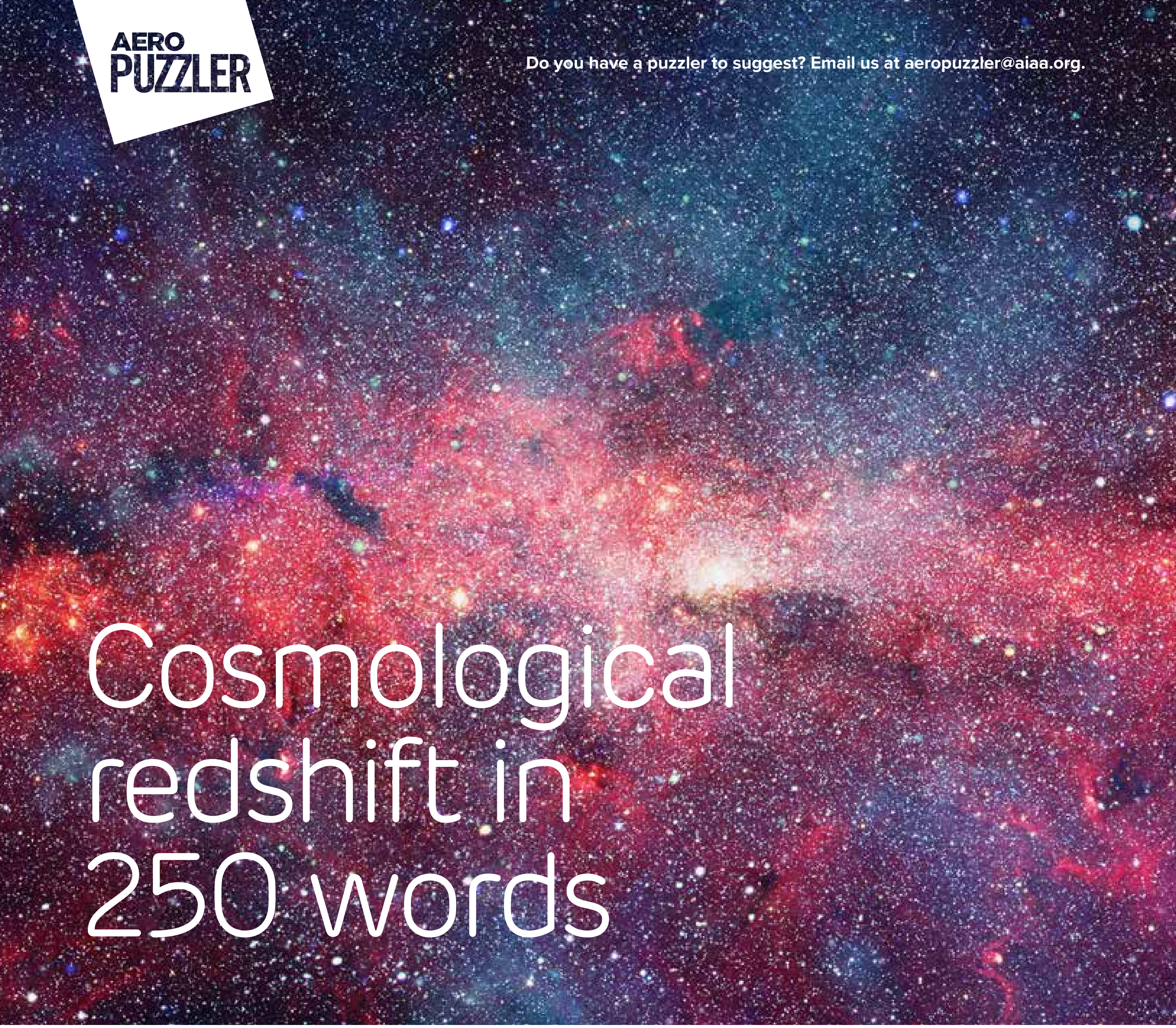
- Public policy priorities for aerospace are clear – maintain stable funding, invest in research, develop technology infrastructure, and develop an educated workforce pipeline.
- Professionals would recommend a career in aerospace to a young person today.
- COVID-19 impacts will continue as the aviation sector recovers.
- Cybersecurity tops the list of challenges facing aerospace and defense.
- Employees expect a demonstrated commitment to DEI from their employers – which they feel is not always being met.

In addition, we partnered with Aerospace Industries Association (AIA) and Ernst & Young LLP to conduct a 2021 Workforce Study released in September, which examines five key focus areas: employee and talent outlook, DEI improvement, the future of work, the A&D industry employee value proposition, and workforce trends. We are energized by the availability of this timely industry data to help fulfill AIAA's commitment to our members and the industry – to solve problems, develop new ideas, and apply technology in creative ways to shape the future of aerospace. ★

Dan Dumbacher
AIAA Executive Director

DOWNLOAD "2021 AIAA State of the Industry Report: The Health and Future Outlook of the Aerospace Industry" Executive Summary and Report at aiaa.org/stateofindustry

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



Cosmological redshift in 250 words

Q. Which phrase would you choose to complete the sentence and why? The Doppler effect fully explains/partially explains/does not at all explain why visible light emitted by the oldest galaxies in the universe will be detected in the infrared by the James Webb Space Telescope.

Draft a response of no more than 250 words and email it by noon Eastern Oct. 16 to aeropuzzler@aiaa.org for a chance to have it published in the November issue.

FROM THE SEPTEMBER ISSUE

NO WINNER: We asked you to suggest a happy ending to a thriller about some terrorists with a bomb and a U.S. president who faces a choice of two kinds of hypersonic weapons to end the threat. We were looking for a response that would probe the trade-offs between air breathing and boost-glide weapons, and suggest a plausible ending. We didn't receive an answer that met that requirement, so unfortunately our notional novel will have to go unfinished.

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

AEROSPACE IN ACTION

What's next for the Inspiration4 capsule?

SpaceX isn't saying (or hadn't by late September), but back in November, former NASA astronaut Michael López-Alegría tweeted that "this very SpaceX Crew Dragon capsule" named Resilience would ferry him and three civilians to the International Space Station and back in January 2022. That flight, Ax-1, is being arranged by Axiom Space of Texas. Now, Axiom isn't talking either.

We do know that the module might have more life left in it. SpaceX has said Dragons can be reflown "at least" five times, and the Inspiration4 flight from Cape Canaveral, Florida, was the second flight for Resilience. ★

▶ This SpaceX photo shows the Inspiration4 capsule after it was hoisted by crane onto the "Dragon nest," the circular platform on the deck of the recovery ship off Florida. The four space flyers were helped out of the capsule moments earlier.

Reality checker

It seems like every day there's a new company vying for a spot in the emerging advanced air mobility market in which electric aircraft would ferry people and cargo over short routes not typically covered by air transportation today. Figuring out which concepts and the companies behind them are "real," as in viable, can be difficult. That's where analyst Sergio Cecutta comes in. His firm SMG Consulting in late 2020 debuted its AAM Reality Index to vet the companies targeting the passenger segment of AAM, sometimes referred to as urban air mobility or UAM. Released monthly, the index is a ranking of manufacturers that SMG has determined are most likely to bring their passenger aircraft to service, based on five factors: funding, leadership, technology readiness, certification and production. The higher a company's ranking, the better SMG believes they are positioned for success. I connected with Cecutta on Zoom to learn more about how the index works and SMG's plans for it. — *Cat Hofacker*

SERGIO CECUTTA

POSITIONS: In 2012, co-founded SMG Consulting in Phoenix, a 10-employee company that focuses on new market analysis for aerospace and defense companies, among other industries. Cecutta remains a partner at SMG. Director of marketing and strategic planning at Honeywell Aerospace, 2010-2011; senior manager of product marketing and business development at Honeywell, 2005-2010.

NOTABLE: Led the development of SMG's AAM Reality Index, which he calls "his baby." The latest edition published in late September lists the 20 air taxi manufacturers SMG deems most likely to enter service, up from the 14 that were in the first edition released in December 2020. At Honeywell, oversaw the introduction and promotion of the Synthetic Vision System for general aviation aircraft in 2007. Came to the United States from Rome in 2000 to work for Honeywell.

AGE: 46

RESIDES: Irvine, California

EDUCATION: Doctorate in aerospace engineering from the University of Rome and Technion-Israel Institute of Technology, 1999. Master of Business Administration from Arizona State University, 2009.

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Q: What is it about AAM that has created this overwhelming amount of interest, perhaps more so than other parts of aerospace?

A: For one thing, engineers are always people with a lot of imagination, they always look at pushing the boundary and the envelope. In aerospace, we've been conservative for many, many years, and I think this is the first time that there is a variety of configurations, there is new stuff. No two AAM vehicles look alike, more or less. Whereas to someone who flies once a year, they likely can't tell the difference between a Boeing and an Airbus; they just know it's got a wing and two engines. So AAM created a lot of excitement, and it also, from a financing industry point of view, created a lot of opportunity that did not exist because aerospace has gone through decades of consolidation, so it was always the same big players. It's also interesting because AAM looks at the part of aviation that's never been looked at: flights within your city or within the proximity of your city as opposed to going 300 miles away or 600 or 1,000 miles away. Because of the battery and distributed propulsion technology we have now, it makes sense financially to do it.

"SMG doesn't want to say who's the most advanced today. We want to say, 'Who's the most likely to make it to the end? Who's the most likely to certify the plane and keep up with their promises of making as many as their business plan says?'"

Q: You've credited Uber's 2017 white paper with sparking the idea for this index. What was it about that document that made the AAM market feel "real" to you?

A: What grabbed my attention is that Uber Elevate co-founders Mark Moore, Nikhil Goel and the team there, they did a good job. Uber Elevate wasn't just the vision of the future, it was something that went into a level of detail where it made sense. It wasn't a piece of science fiction; there was that depth of technical detail, it had business potential, so it started to make a lot of sense that this industry was coming. It felt a little bit like the technologies that had created these cars with Level 3 and Level 4 autonomy were now coming to the aerospace industry. And then as we at SMG started to get to know the industry and the people, we were more and more convinced that this was the birth of something as opposed to a fluke. Moving into 2019 and 2020, the Vertical Flight Society with Mike Hirschberg was doing a great job cataloging all the companies out there, but we started to ask ourselves "Which ones are the companies that we want to work with? Which are problematic?" That is when the index was born. So there's two things that we have purposefully done. Number one is we have no interest in classifying all the companies. There's way too many, and I don't think it matters anyway; any industry has a long tail that then withers away, and it's just normal for any new industry. With these 20 companies that we've chosen for the index — and we're going to add a few more — the idea is we're measuring not the instantaneous progress of these companies. SMG doesn't want to say who's the most advanced today. We want to say, "Who's the most likely to make it to the end? Who's the most likely to certify the plane and keep up with their promises of making as many as their business plan says?"

Q: And none of the companies are paying to be on this list.

A: Correct. We wanted to make sure the index is data-driven. I like data because you can question my assumption, but you can't question my data. So when we have someone that says, "Well, I think that score is wrong," my response is, "As long as we agree with the order of the ranking, the actual number is less important." We are very lucky that all the [original equipment manufacturers] open their doors to us with the distinction that some OEMs just tell us the public information. Some other OEMs tell us more than the public information, and the beauty is that the way the index is built, we can incorporate nonpublic information without disclosing it. For example, if a company has opened a plant but they haven't announced it, we can incorporate that into their ranking without going into detail. We can just say, "production readiness increased."

Q: To me, it seems like certification and production are the biggest indicators of success and therefore should be weighted more heavily.

A: What you say is not wrong, so without going through a lot of detail, yes, those are the two big issues in this industry. For the index, we put weight on which one of the five buckets is the most important. And then through a formula, our algorithm comes up with a value on a scale of 1-10. We wanted something simple that can be easily compared because in advanced air mobility, many times we have these "it depends" scenarios. There are a million nuances that go into each company, at the very least, you can compare certain things between companies. And we've thought about updating the formula, but for now we don't want to for the simple reason that every time you update a formula, you break the comparison with the past. Never say never, but I wouldn't foresee changing the way we calculate it.

Q: One metric missing from this list that will surely factor in is public acceptance. How do you account for that aspect?

A: In aerospace, we always say no one competes on safety. Whatever the FAA, whatever EASA dictates as the threshold for certification, we're going to meet it. But I would agree with you that public acceptance is important. We are probably going to think about capturing it when we look at operations, as opposed to the vehicles, because a vehicle will be safe for the public or it's not going to be certified. But when it comes to public acceptance, that is something we need to think about when it comes to operations. I always call it the beehive problem: You don't hear one bee, but you hear a beehive. It's the same thing here. You might not hear one vehicle, but when you've got hundreds, is it going to change? Many times we don't know until we know, so that's why NASA is doing these acoustics tests right now with the [Advanced Air Mobility] National Campaign. That is great because it's the first time that we can simulate in real life how these flights are going to work.

A full-sized prototype of Joby's proposed electric-powered aircraft lands at the company's Electric Flight Base in California in July. The aircraft completed 11 circuits above the flight base on one charge during the 77-minute flight, the equivalent of traveling 240 kilometers. The company has been ranked No. 1 on the AAM Reality Index since May.

Joby Aviation/YouTube

Q: So you're thinking of public acceptance in terms of noise levels. It seems like another big aspect will be the long-term plan to shift to autonomous flights.

A: Autonomy is a complex issue. I don't think it's anything short term. If you look at the AI Roadmap that EASA has issued, they're talking about what we really think of as full autonomy by the first half of the 2030s. So it's not anything that's going to happen tomorrow, but in the nearer-term, if people aren't going to fly in these vehicles once companies start entering operations, then it's a moot point to even talk about anything more complex. That's why there is a not-for-profit organization called CAMI, the Community Air Mobility Initiative, that's doing a lot of great work with the cities, with residents, to educate people about these vehicles. Because if you say "air taxi," people think about "The Jetsons," they think about "Star Wars," and that's not the way it's going to be. My way to think about it is an urban network. We don't want to use the "airline" word,but it's going to be a network similar in principle to an airline model for a few years until this industry grows in size: regularly scheduled flights within a city or to close-by cities.

Q: That's the grand vision a lot of these companies are articulating, but there's so many of them that I wonder if there is a bubble that's going to burst at some point.

A: "A bubble going to burst" seems like a negative connotation. There's going to be consolidation because there's just too many companies right now. I think the market is big enough, it's just how far away is the market. What I see is that companies — especially the top companies — are taking a very pragmatic approach to this. Some of the numbers might look big because we've never seen them as far as production, but at the same time they're taking a pragmatic approach: "We need to do this, and we need to do this, and we need to do this." At the beginning, I think Uber introduced us to these visions of 2040 with these skyscraper-sized vertiports. It was a good way to get the juices flowing, to get interest in the market. But now we're at the point where we say, "OK, great, one day we will have a thousand-foot-tall tower for landing AAM vehicles. What's coming tomorrow?" This pragmatism will avoid a bubble bursting, so it's going to be more like when you're stirring two liquids; it's just going to coagulate into something more homogeneous. I don't see it as a jarring explosion of a bubble.

Q: Once the dust settles, most of the companies I've talked with aren't envisioning a market that's as large as the auto industry, for example. What is your sense?

A: Aerospace is expensive. Not that automotive is not expensive, but the fact is that there are a lot more people that will always have cars than will be flying in airplanes. That's an inevitability, at least for the next 20, 30 years. But the beauty of the AAM market is that it's made up of many different pieces. There's going to be a cargo market that we think is going to be healthy and grow really quickly. The goal of Amazon is to deliver your order in 30 minutes, by AAM vehicles, autonomous drones or even autonomous trucks. In some parts of the U.S. outside of the big cities, it takes two to three days, and so these vehicles will help with the demand for "Can I have it tomorrow?" Or us in the big cities, "Can I have it in an hour?" On the other side, the passenger air taxi market is also a big opportunity. We've always looked at a regional market or a country or international. You go to LA from San Francisco, you don't go to LA from Orange County. When it comes to the numbers, we at SMG think that market is big. As to whether it's big in the hundreds of billions of dollars or the trillions, that's a problem for 20 years from now. Today, it's enough to say we recognize that it's a healthy market because it's a new form of transportation that some cities desperately need. That's an opportunity for the consumer. We used to say, "Are you doing a bus, the subway or the taxi?" Now it's the subway, taxis, you can take an Uber, you can take a scooter. At a certain point, we'll say "Why don't you take an air taxi?"

Q: Every new edition of your index brings a new ranking or piece of news. Do you anticipate things leveling out at some point?

A: Yes. Right now we're in that time of the market where we are progressing through certification, flying subscale prototypes, full-scale prototypes, they're establishing their production facilities. Soon, they will start flying formal aircraft for certification. Once their airplane is certified, their production is started, I would see this plateauing more with progress taking more time, for the simple reason that at a certain point, someone will get to the magic number 10 on our index: They have a viable business with network operators and thousands of airplanes. Right now, there is more churn because it's more companies, and schedules are changing — "We're going to do a flight. No, flight is delayed." There is a lot of movement right now, where you see some jockeying for position. But at the same time, if you look at Joby Aviation and you go back a few indexes, they're always there at the top.

Q: Is Joby's consistent ranking at the top of the index a good predictor of their future success?

A: Joby has been around since 2009, and it takes time to develop this technology. When they started, there was no electric aviation industry, so they had to figure it out on their own, a little bit like Tesla. But Joby has a great team. They are very pragmatic with what they're doing. They are very result-oriented; they will never make noise unless there is something to talk about. And if you look at the number of flights, they're the company that has flown the most with a full-scale prototype. As far as certification, they are probably one of the most advanced out there. On the production side, they're working with Toyota, one of the best companies in the world as far as production. If you look at some of the other top companies on the index, they share this pragmatism and they're also putting all the right pieces in place. That is very important because no one is going to do it all, but choosing the right partner is a big step toward success.

Q: The metrics in your index seem like a good recipe for success, but what other common traits do you see in the most promising AAM companies?

A: The leading companies are all about execution, and no, it doesn't sound sexy. A lot of these technologies will soon be mature enough that the FAA can feel comfortable certifying it, so now it's a matter of execution. That's not going to be easy because it brings in problems of scale and complexities that we're not familiar with in aerospace. Beyond that, it gets hard to identify common traits because while the definition of AAM is that it's enabled by electrification, distributed propulsion and autonomy, it encompasses a big number of markets and use cases.

Q: Looking to the future in 10 years or so, what is the role of the AAM Reality Index going to be if these company predictions come true and they are operating passenger flights?

A: That's a good point. We don't think the index is this cure for all the evils. At a certain point, I think it will serve its mission. We want to have multiple indexes in the future — for operators, we want to have indexes for infrastructure — because there's company progress. Maybe someone gets almost at the top of a vehicle index, so now you start your work as an operator. So at a certain point I think the Reality Index will become historical. We also think about this industry being solid in another six, seven years, by the end of the decade, so it's about looking ahead to what's next for us. The whole idea is that when another AAM revolution comes around, we don't want to miss it. You have to consider that this step into automation is going to be a big change, so that might reshuffle the orders on our index in some way. Maybe the company that was No. 1 in piloted operations won't be No. 1 when they go autonomous. That's going to be another step change that I think is still going to make the index important, but this is not meant to be something that's still around by 2040. I hope that the industry has something cooler at that point. ★

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Nominations, together with all relevant supporting material, should be sent to Prof. Tal Shima, Dean of Aerospace Engineering, Technion – IIT, Haifa 32000, Israel (aedean@ae.technion.ac.il) by October 23th 2021.

The prize will be awarded in 16-17, March 2022 at the Israel Annual Conference on Aerospace Sciences, which the winner must personally attend. In addition, he/she will give at least two public lectures at the Technion.

(The Hanin Endowment will cover the winner's accommodation and travel expenses, up to 5000$).

Averting war in space

China and the United States are on a dangerous collision course as they eye the moon and Mars as repositories of natural resources. Can the peace in space be kept? Sarah Wells went looking for answers.

BY SARAH WELLS | sarahes.wells@gmail.com

At just after noon Eastern time in the United States on Thursday, July 17, 1975, a group of five men changed the trajectory of space exploration. Citizens in the Soviet Union and the United States watched grainy, live TV coverage as an Apollo service module and command module moved into a circular orbit around a Soviet Soyuz craft and prepared to dock.

Three hours later, cosmonaut Alexei Leonov, the Soyuz commander, and astronaut Thomas Stafford, the Apollo commander, grasped hands across the transfer corridor linking the two spacecraft.

"Glad to see you. Very, very happy to see you," Leonov told Stafford in English.

The Apollo-Soyuz "handshake in space," as history knows it, became the springboard for today's collaboration aboard the International Space Station. The United States and Russia, the heir to the Soviet space program, have so far kept their Earthly tensions from spreading to space in a significant way, even in the Putin era.

These days, however, Russia is not the nation with the boldest space ambitions compared to those of the United States. Leading the way is China. The China National Space Administration, CNSA, landed its Zhurong robotic rover on Mars in May, after returning lunar soil samples home to China from the Chang'e 5 lander in 2020, which followed landing the Yutu-2 rover on the moon in 2018 and the original Yutu in 2013. Closer to Earth, CNSA is assembling its own space station, Tiangong, and since June has had three taikonauts aboard the planned station's core module Tianhe. A state-owned Chinese rocket manufacturer also announced in June that it plans to undertake its first crewed mission to Mars in 2033.

The situation, arguably, bears some resemblance to the space competition between the Soviet Union and United States in the 1960s and '70s, although this one involves deep space as well as Earth orbit. Could a handshake moment be coming between American astronauts and Chinese taikonauts? None of the half-dozen space lawyers, analysts, retired generals and historians I spoke to for this article thinks so. They see no evidence that China and the United States are engaged in the kind of diplomatic outreach that pre-

▲ NASA astronaut Thomas Stafford (foreground) and cosmonaut Alexei Leonov make their historic handshake in space after the Apollo and Soyuz spacecraft docked and the hatch was opened. This grainy image was made from a frame of 16 millimeter motion picture film. In the other photo, the commanders pose for a photo taken with a 35 mm camera.

NASA

ceded the Apollo-Soyuz mission. This lack of diplomacy has some experts calling for establishment of clear rules for all space actors, especially China and the United States. Otherwise, the world risks learning the hard way that these adversaries overestimated their ability to fight safely in space, without endangering the satellites that are vital to civil society and global commerce.

Gauging intent

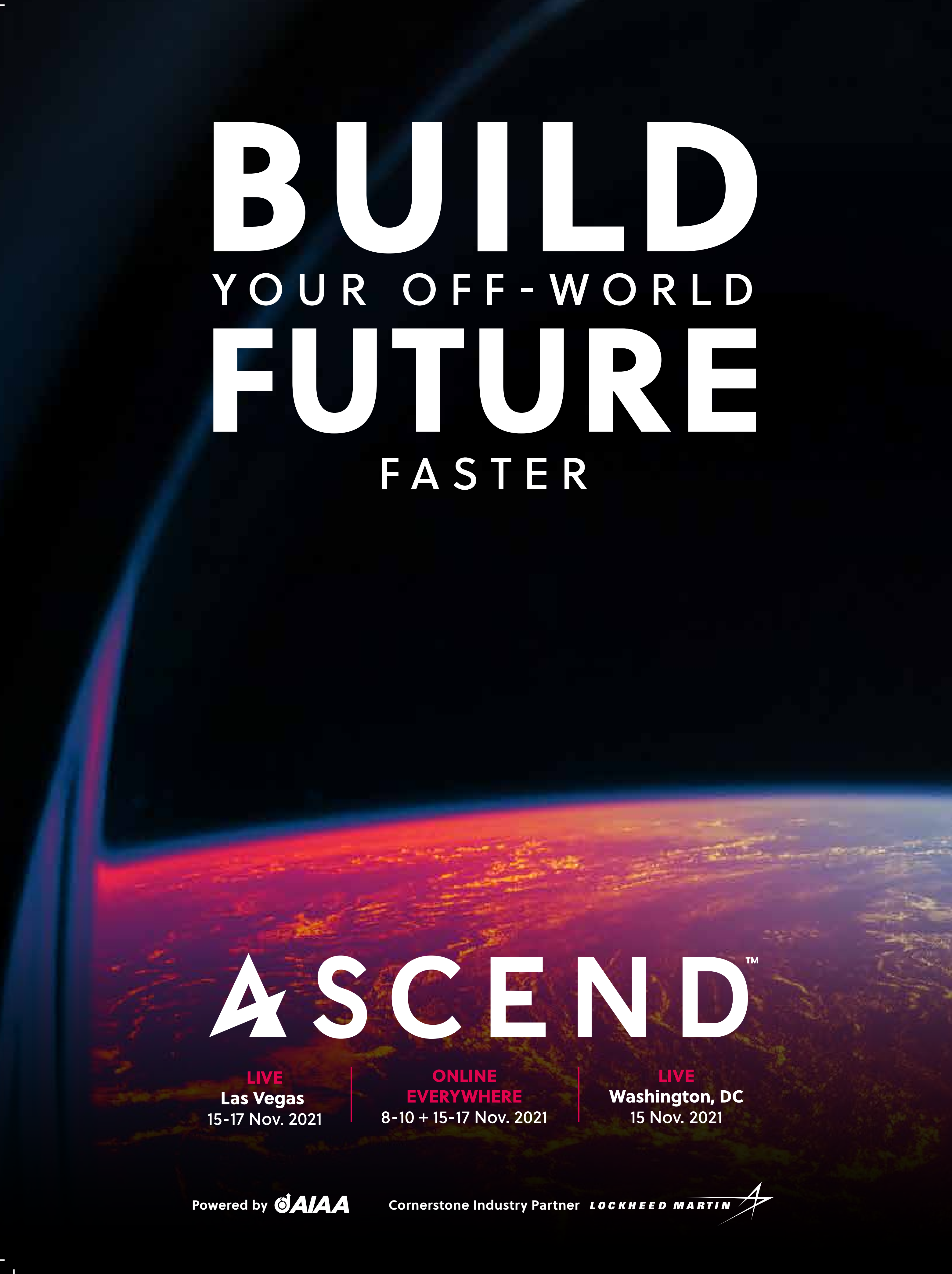
For its part, China asserts that its intentions in space are peaceful. According to Liu Pengyu, a spokesman for the Chinese Embassy in Washington, D.C., China's overarching goals are to "improve mankind's scientific understanding of the universe, expand and extend the space for human activities and advance the sustainable development of human civilization."

The United States remains more than skeptical. According to the 2021 Annual Threat Assessment report from the U.S. Office of Director of National Intelligence, China is continuing to "field new destructive and nondestructive ground- and space-based antisatellite (ASAT) weapons" that will be "integral to potential military campaigns by the PLA [People's Liberation Army]." With more government and commercial satellites in orbit than any other nation, the United States affords China with lots of potential targets.

In part as a response to this rising action, the United States created the U.S. Space Force in 2019. Among its activities, the new service is funding the next generation of ground-based satellite jammers, the Counter Communications System Meadowlands. Each Meadowlands system, consisting of signal processors and other equipment, is a non-kinetic weapon and a sleeker successor to the U.S. Air Force's Counter Communications System that began operations in 2004.

A complicated history

Collaboration in space between China and the United States has been tried before. In the 1990s, the U.S. briefly permitted commercial satellites built in the United States to be launched on Chinese Long March rockets, an experiment that ended in 1999 when a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▲ Chinese taikonauts trained for the first time with non-Chinese space flyers in 2017 when two European Space Agency astronauts joined them for nine days to practice water recoveries. Such collaborations are rare.

European Space Agency

congressional investigation concluded that U.S. contractors illegally transferred rocketry "know-how" to China in hopes of improving the nation's success rate for launch customers. The relationship soured further a decade ago, when an amendment was introduced in a 2011 department of defense appropriations bill that prohibited bilateral cooperation between the U.S. and China in space. Originally proposed by then-Rep. Frank Wolf, who alleged that China hacked his office's computers in 2006, the "Wolf Amendment'' has been included and made binding in every defense appropriations bill since 2011, including in 2021.

"It has persisted because a large bipartisan majority on the appropriations subcommittee still support it," says Gregory Kulacki, manager of the China Project at the Union of Concerned Scientists.

This amendment makes it so that NASA and CNSA cannot work together without a certification from the FBI and congressional approval. This certification includes verifying there's no risk of sensitive information sharing and that Chinese officials involved have no direct connection to the violation of human rights. The FBI gave that certification when NASA's Lunar Reconnaissance Orbiter helped track CNSA's rover Yutu 2 in 2019. While Kulacki says the Wolf Amendment cannot be held directly responsible for China's absence from the ISS — opposition to it joining and growing disinterest from the Chinese to join predate the introduction of the amendment — it does limit China's future participation.

"As long as the amendment remains, it is not even possible for NASA to talk to China about the possibility of Chinese participation," he says.

The amendment also came close to banning U.S.-based Chinese scientists from the Kepler Science Conference II at NASA's Ames Research Center in 2013 before language was clarified prior to the conference that same year to allow Chinese scientists to participate in such events.

In the view of Kulacki, the Wolf amendment cut off the U.S.-China relationship at the worst possible time.

"There was a window when the Chinese really wanted to cooperate with the United States and meaningful relationships, both institutional and personal, were being built, but that window is closed now," he says. "The Chinese have no real motivation to put up with the politicizing of space science and exploration that has happened because of these restrictions in the United States."

The Wolf Amendment and the funding whims of American politicians from one presidential administration to the next make the United States an unappealing collaborator from the perspective of China, he says.

Even if the two nations did want to collaborate, there is disagreement about who should be the first to mend this relationship.

"China seems to be trying to pick fights with the West. And to what goal I don't understand," Mike Griffin, who was NASA administrator during the George W. Bush administration and chief technology officer in the Trump Pentagon, told Aerospace America in an interview. He was referring to the islands China has built in the South China Sea to claim sovereignty over the surrounding waters. "Collaboration with China in deep space seems to me to be dependent more upon their behavior than ours."

China's view is just the opposite, based on my discussion with Liu at the Chinese Embassy over the possibility of American-Chinese collaboration: "The ball is on the U.S. side," Liu says.

For China, its antipathy likely dates back to the 1955 U.S. deportation of engineer Xuesen Qian. As experts in space history told the BBC in 2020, Qian came to the U.S. in 1935 to study aero- and astronautical engineering, eventually arriving at Caltech in California. There, he made friends with members of the university's "Suicide Squad" — so named because the group was attempting to build a rocket on campus.

The squad's rocket work came to the attention of the U.S. government, which in 1943 provided funding to create the Jet Propulsion Laboratory under the direction of Qian's academic mentor, Theodore von Kármán. Qian and other Suicide Squad colleagues were given top-level security clearances for the government-funded project.

But then, anti-communist McCarthyism spread across the United States in the 1950s. Both Qian and another member of the Suicide Squad were accused of being members of the Communist Party. After five years of partial house arrest in California, Qian was deported to China with his wife and two American-born children. According to the BBC, after the experience Qian swore to reporters that he'd "never step foot in America again."

Qian's house arrest and deportation were far from the end of his scientific career, however, and in China he is known as the "Father of Chinese Rocketry."

"The origins of the two space programs are tied up in this one very interesting Chinese individual," says Kulacki of the Union of Concerned Scientists.

While this icing out of China in the early days of the American space program may have slowed China's progress initially, Kulacki says the lasting impact was to make China's National Space Administration more self-reliant. While China does have a history of collaborating with other international space programs, including the European Space Agency, it might be too late to change courses with NASA.

"I think China's relatively independent now, and really doesn't need the United States at all to continue making substantial progress in space," Kulacki says.

Though lauded for its exploration achievements, China has also faced international criticism for its go-it-alone approach in other areas, such as when debris from a Chinese rocket reportedly fell into the Indian Ocean in May. While there was no damage, NASA Administrator Bill Nelson said in a press statement at the time that China was "failing to meet responsible standards regarding their space debris."

Modern day

China's military space program might also be larger than it seems. CNSA, an ostensibly civilian agency, has gained a foothold in space exploration and technology, but its stature in China is sometimes misunderstood in the West, said Dean Cheng, a senior research fellow at the Heritage Foundation focusing on Asian studies and foreign policy.

"It is very, very low down on the bureaucratic totem pole, and really doesn't have anywhere near the authority of NASA," Cheng says.

NASA's work is largely distinct from the Pentagon, but the Chinese military has tight control over how things are done at CNSA, including where, when and how rockets are launched, says Cheng.

"Everyone who is part of that staff, whether they are in uniform or not, are in the military," says Cheng, referring to CNSA's launch bases.

Beyond CNSA, Cheng says it's really the People's Liberation Army Strategic Support Force that has military control over space efforts as well as electronic and cyberwarfare. In this way, the PLA's Strategic Support Force includes elements that are the functional equivalents of those of the U.S. Space Force, National Security Agency and Space Command, he says.

Another difference between CNSA and NASA, says Cheng, is CNSA's relative lack of transparency when it comes to sharing both funding and data.

"We do not have a figure on China's space budget, not even broad outlines," says Cheng. "We simply don't." He says the program is even "more opaque" than that of the Soviet Union before its dissolution.

As for CNSA's data sharing, it has historically been slower than that of NASA, which has an open access model for sharing its planetary and cosmic data (such as the chemical composition of Martian soil) with the international scientific community. Similar data from CNSA's Zhurong rover has been slow to reach research scientists beyond China, says Jim Bell, an Arizona State professor of planetary science and principal investigator for the Mastcam-Z imaging system on NASA's Perseverance Mars rover.

"There was a window when the Chinese really wanted to cooperate with the United States and meaningful relationships, both institutional and personal, were being built, but that window is closed now."

— Gregory Kulacki, Union of Concerned Scientists

For Cheng, the slow sharing of scientific data does not amount to a national security concern, but the technology that enables these missions could be a potential threat.

"Going to Mars in and of itself doesn't really create a threat," says Cheng. "The issue is that in order to get to Mars you need deep space tracking capabilities and you'll also want a network of Earth-based observation posts so that you can track your Martian probes."

And if you can track your own probes using this technology, there's no reason you couldn't track other spacecraft as well, including U.S. satellites in geostationary and low-Earth orbit, Cheng says.

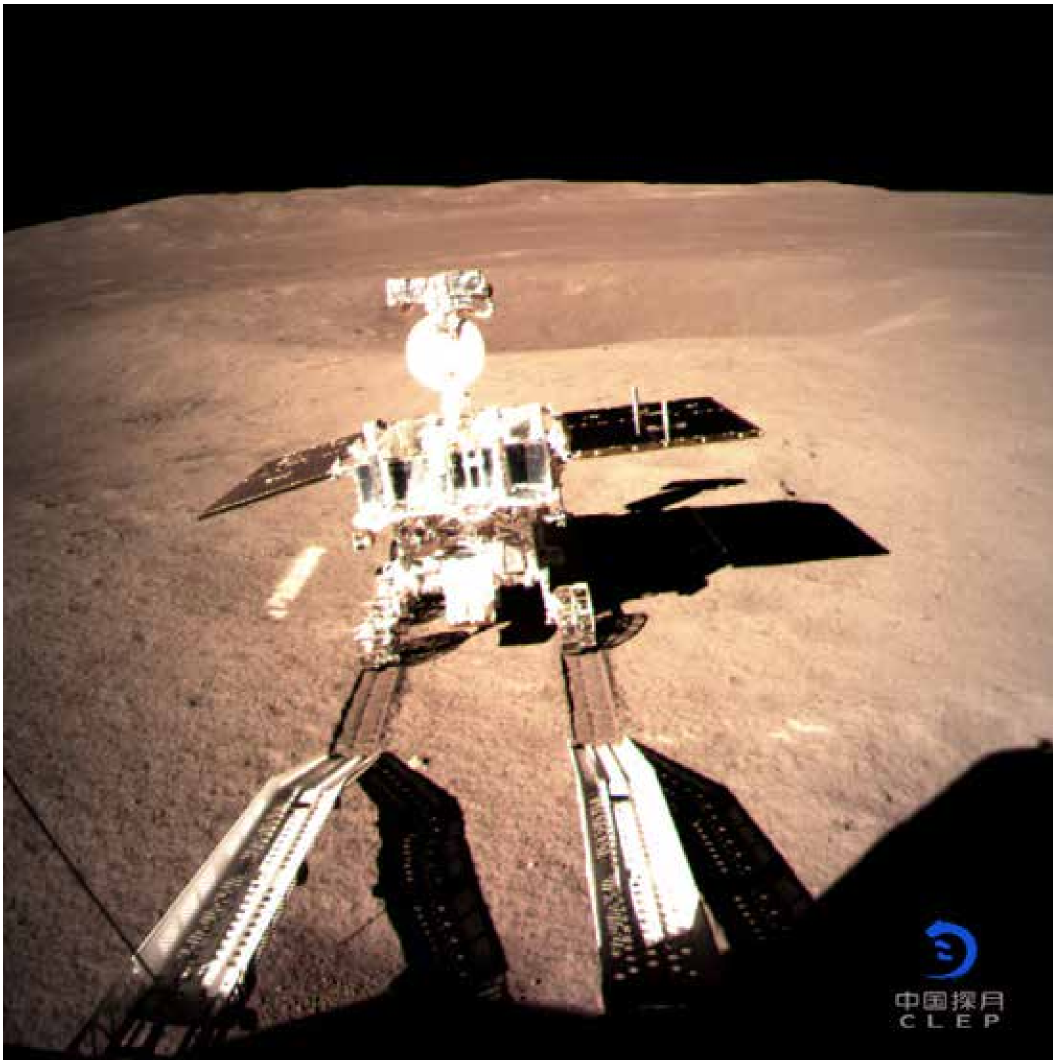
A new road map

Simply put, there aren't going to be rover wars on Mars, or even the moon, predicts Cheng. These scientific experiments are too expensive and too far away to be dragged into such a fight. But perhaps the same can't be said for objects in low-Earth orbit, such as satellites, or even potentially resources on the lunar surface, says retired U.S. Air Force Gen. Robert Kehler. During his military career, Kehler commanded Air Force Space Command and later U.S. Strategic Command.

"The United States has said clearly that we believe that there is a high likelihood that a future conflict will either begin or quickly extend into space," says Kehler. That view raises space to the same level as air or sea as a possible war-fighting domain. Such fights may encompass technology that jams or dazzles satellites or anti-satellite weapons that would even shoot satellites out of orbit.

This evolving swath of space activities is made only more complicated by the introduction of commercial space companies into the mix, says Kehler. For example, if an India-funded lunar mining company from the UAE happens to break a U.S. law, who is at fault and what would be the redress? The United Nations attempted to lay the groundwork for answering future questions like these in 1967 when it adopted the Outer Space Treaty. Among other principles, the treaty states that "outer space is not subject to national appropriation by claim of sovereignty." This treaty, however, did not anticipate the rise of commercial space companies looking to exploit space independently of national governments.

In an attempt to build on this treaty, the U.S. in 2020 laid out a separate common set of standards for how nations — and their commercial companies — should conduct their research on the lunar surface called the Artemis Accords. The accords seek to protect "historically significant human or robotic landing sites," like China's rovers or the U.S. American flag. It also lays out guidelines for resource extraction, including that they should be "safe and sustainable." Other language details how nations should interact: "the Signatories commit to seek to refrain from any intentional actions that may create harmful interference with each other's use of outer space in their activities under these Accords." While 12 countries including the UAE, Japan and the United Kingdom



The Chinese Yutu-2 rover after it rolled off the Chang'e-4 spacecraft on the moon in 2019. NASA's Lunar Reconnaissance Orbiter helped track the rover, marking one of the times the two countries collaborated within the provisions of the Wolf Amendment.

Chinese National Space Administration

have signed these accords, China and Russia have not.

In the view of Kehler, the Artemis Accords and Outer Space Treaty are simply not strong or specific enough. "I think it's time for the international community to get very serious about what's called the 'rules of the road,'" he says. "The current regulatory structure is grossly inadequate [for] what's really happening and what's about to happen," he says, referring to the tremendous growth of commercial space exploration on the horizon.

One promising path forward, says Joanne Gabrynowicz, a professor of space law at the University of Mississippi and editor-in-chief emerita of the Journal of Space Law, would be to treat space and celestial surfaces — whether they be planets, moons or comets — as a global commons, similar to international waters. This is something already being discussed at the U.N. by the U.S. and Luxembourg, which has plans to become Europe's space mining hub.

"Luxembourg and the U.S. both accept the high-seas analogy when it comes to space resource extraction," says Gabrynowicz. "The Pacific Ocean can't be claimed by any one nation but fish can be extracted from it."

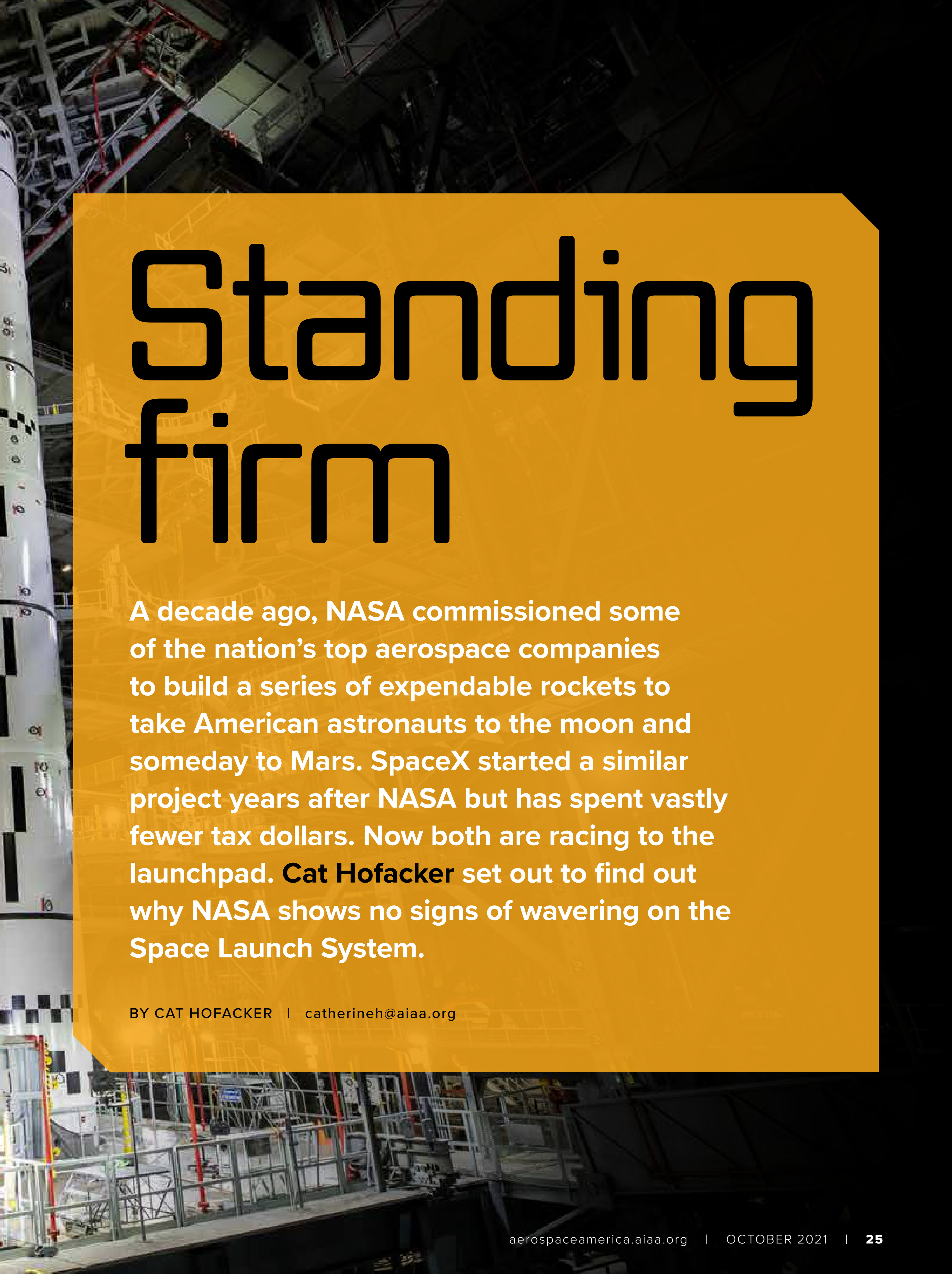
"The question arises about what can be done with the extracted resource," continues Gabrynowicz. "The U.S. view is that like the fish, once a space resource is extracted it can become property. The Luxembourg view is that an international multilateral framework must be developed to address the status of extracted space resources."

So is a handshake the answer? Cheng has a firm opinion about this.

"Could the U.S. and China cooperate?" he asks. "Yes, we could certainly have a one-off. But if you think that's going to somehow either change U.S. China relations or lead to deeper space cooperation, you're going to have a skeptic on your hands."

Ultimately, it will always be political partnerships and discussions on Earth that impact behavior in space, and not the other way round, he says, even as beautiful as the Apollo-Soyuz handshake might have looked from the outside. ★

NASA's color scheme for the Space Launch System resembles that of the space shuttle fleet. The orange on the core stage in this photo is the natural color of the insulation, and just as with the shuttle's external tank, NASA elected to save weight by not painting it. The core is flanked by white solid rocket boosters in the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida.
NASA



Standing firm

A decade ago, NASA commissioned some of the nation's top aerospace companies to build a series of expendable rockets to take American astronauts to the moon and someday to Mars. SpaceX started a similar project years after NASA but has spent vastly fewer tax dollars. Now both are racing to the launchpad. Cat Hofacker set out to find out why NASA shows no signs of wavering on the Space Launch System.

BY CAT HOFACKER | catherineh@aiaa.org

▲ Then-U.S. Sen. Bill Nelson, D-Fla., talks at a press conference on Capitol Hill in 2011 at which an early design of the Space Launch System was shown. Behind him from left are Sen. Kay Bailey Hutchison, R-Texas; Sen. John Boozman, R-Ark.; Rep. Chaka Fattah, D-Pa., and then-NASA Administrator Charlie Bolden.

NASA

When Virginia Barnes retired from Boeing in 2015, her colleagues gave her four poster board-sized tickets resembling the giant checks given to TV game show winners. The golden cardboard slabs were printed with these words: "ADMIT ONE, SLS First Launch," at the time thought to be just a few years off.

Barnes is still waiting to cash in her prize, but perhaps not for much longer. The inaugural launch of the Space Launch System, the expendable rockets that will deliver astronauts to lunar orbit ahead of surface landings, might now be just months away.

The uncrewed launch will be a big moment for NASA, but perhaps not a triumphant one, even if all goes as planned. The launch is four years overdue, and the program's anticipated cost has doubled to $20 billion. That figure doesn't include the $18 billion spent developing the Orion crew capsules that would fly atop the rockets, plus the necessary upgrades at the launch pad at NASA's Kennedy Space Center in Florida. The delays and cost overruns have led to hard questions from outside analysts over whether NASA, in fact, still needs its own fleet of deep space rockets, given the number of companies developing their own heavy-lift vehicles, including SpaceX, whose Starship is the farthest ahead and most comparable to SLS in terms of throw weight. The first Starship could reach space about the time the first SLS does.

"Maybe three to four years ago, SLS filled a hole in the market," says Jordan Noone, co-founder and partner at Embedded Ventures, a California venture capital firm that funds innovative space infrastructure startups. "Now that hole is being rapidly closed in the commercial sector" because companies including SpaceX have drastically reduced the cost of launch, freeing up startups to focus on markets including optical comms.

NASA shows no signs of second thoughts, if it is having any. Why is that? Casey Dreier, the senior policy analyst at the California nonprofit The Planetary Society, has a theory: SLS "is the essence of the agency, so it has a high symbolic value," he says. "It has to succeed."

This account of NASA's unwavering support of the long-delayed and over-budget SLS is based on reviews of agency planning documents, reports from the NASA Office of Inspector General and the congressional Government Accountability Office, as well as interviews with analysts, space industry executives and a half-dozen current and former leaders from Boeing and NASA.

A monster rocket

It was March 2019, and then-NASA Administrator Jim Bridenstine was testifying in front of the U.S. Senate Commerce Committee. The committee backed SLS, but it was getting harder and harder to do so. The inaugural SLS flight to send an unoccupied Orion capsule around the moon was in danger of slipping to the right — again. Committee chair Sen. Roger Wicker, R-Miss., in whose state NASA tests the majority of the SLS hardware, pressed Bridenstine about NASA's efforts to keep the June 2020 target date.

Bridenstine paused for the barest second. Then, speaking slowly and appearing to take great care in choosing his words, he said NASA was studying whether two commercial heavy-lifters might instead conduct the mission. One rocket, such as a Delta IV Heavy from United Launch Alliance, would blast the 22.7-metric-ton combination of Orion crew module and service module that weigh roughly the same as two orcas to low-Earth orbit. Another rocket, perhaps a SpaceX Falcon Heavy, would launch the upper stage that would set the capsule on a trajectory to lunar orbit.

The proverbial Washington walk-back quickly ensued. The day after the hearing, NASA posted the text of an email from Bridenstine to the NASA workforce on NASA.gov, which emphasized that the agency "is committed to building and flying the SLS" in part because "launching two heavy-lift rockets to get Orion to the Moon is not optimum or sustainable." The message seemed to be: Please don't misconstrue multiple commercial rockets as a possible long-term alternative to SLS.

The exchange illustrates the two central questions about the necessity of SLS. The first is philosophical: What is NASA's unique role that can't be filled by space companies designing and building their own rockets with their own dollars? The second is technical: Why a big rocket?

The answers lie in the chain of events that led to the creation of SLS.

February 2010 was a gloomy month for those inside and outside of NASA who believed that, no matter what concepts might be percolating in the private sector, NASA needed its own fleet of space launch vehicles to ensure American leadership in human space exploration. The first disappointment was that NASA's 2011 budget request proposed zeroing, rather than replacing, the George W. Bush administration's Constellation moon program and its in-development Ares rockets. These would have blasted crew capsules and landers to Earth orbit to prepare for lunar surface missions.

The second disappointment was less surprising. The request reflected the long-standing plan to retire the space shuttle fleet, meaning that the United States would need to buy seats on Russian Soyuz capsules to get astronauts to and from the International Space

Teamwork

- Core stage: Boeing (with four RS-25 engines from Aerojet Rocketdyne)
- Two solid rocket boosters: Northrop Grumman
- Launch vehicle stage adapter: Teledyne Brown Engineering
- Interim Cryogenic Propulsion Stage: Boeing, United Launch Alliance (with one RL-10B2 engine from Aerojet)
- Orion crew capsule: Lockheed Martin
- Orion service module: Airbus, funded by the European Space Agency

First launch

The inaugural flight of a Space Launch System rocket will, if all goes as planned, boost an unoccupied Orion capsule into lunar orbit in a rehearsal for a similar mission with four astronauts, currently targeted for late 2023 or early 2024.

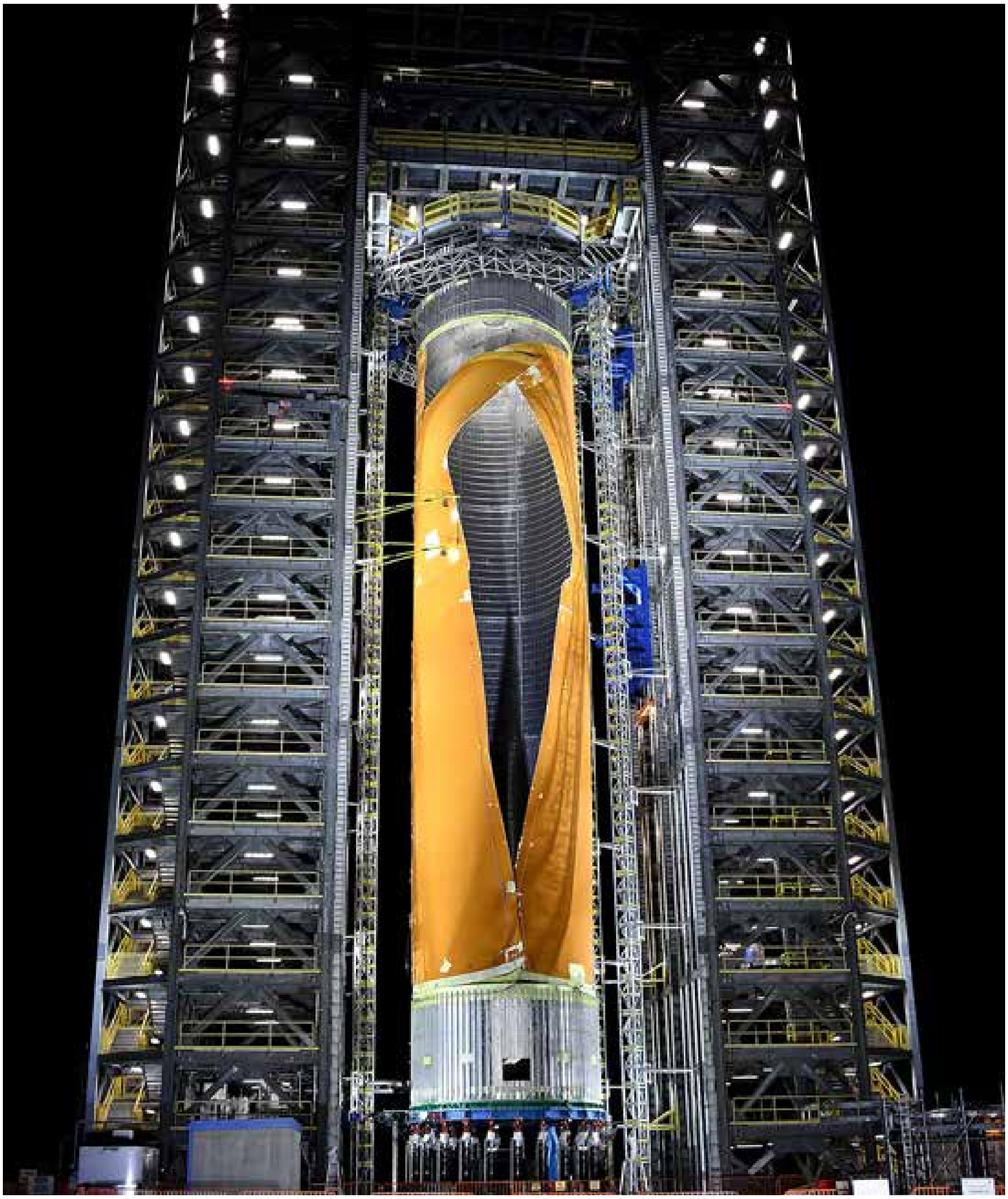
NASA and its contractor Jacobs have been stacking the rocket for this Artemis-1 mission since January inside the same Vehicle Assembly Building where the space shuttle orbiters were readied for launch. After the Orion crew capsule is installed, probably in late October, NASA plans to announce a specific launch date. The agency has shifted to saying by "the end of the year," and most recently Administrator Bill Nelson has tagged on "or the first part of next year."

The SLS core took six years to build and test, but on launch day its four RS-25 engines will fire for just eight minutes. Similar to shuttle launches, the engines ignite seconds before T-0, at which point the two solid rocket motors ignite. That will be enough to lift the stack off the pad and accelerate it to the speed of 11 kilometers per second needed to reach orbit.

About two minutes into the flight, the solid rocket boosters will shut down and separate from the core stage, tumbling toward the Atlantic Ocean. At an altitude of 161 kilometers, the RS-25 engines will cut off and the core stage will follow the boosters to their watery resting place. RS-25s were flown multiple times on the shuttle orbiters as the Space Shuttle Main Engines, as were some of the boosters, but the Artemis-1 engines won't be recovered.

At this point, SLS's Interim Cryogenic Propulsion Stage will ignite its single RL-10 engine to propel Orion and its solar panel-equipped service module toward the moon. After separating from this stage, Orion will fly within 100 kilometers of the lunar surface and then out to a distance of 70,000 kilometers beyond the moon, aided by lunar gravity. After six days of orbiting the moon, the service module on Orion will fire its thrusters to place the spacecraft on a trajectory toward Earth. After separating from the service module, the Orion crew module will splash down in the Pacific Ocean under parachutes, as though it were bringing a crew home.

— Cat Hofacker



Engineers deliberately pushed a test version of the Space Launch System's liquid hydrogen tank past the breaking point as part of routine tests at NASA's Marshall Space Flight Center in Alabama.

NASA

Station. For the longer term, the budget proposed funding the development of privately owned spacecraft that would transport NASA astronauts to ISS under contracts.

When the request landed, the behind-the-scenes fuming began. Space executives and some U.S. lawmakers were deeply unhappy that the 2011 budget request had simply ended Constellation. Among those upset was former astronaut Charlie Bolden, the NASA administrator at the time. The White House's Office of Management and Budget had overruled the agency's original budget submission.

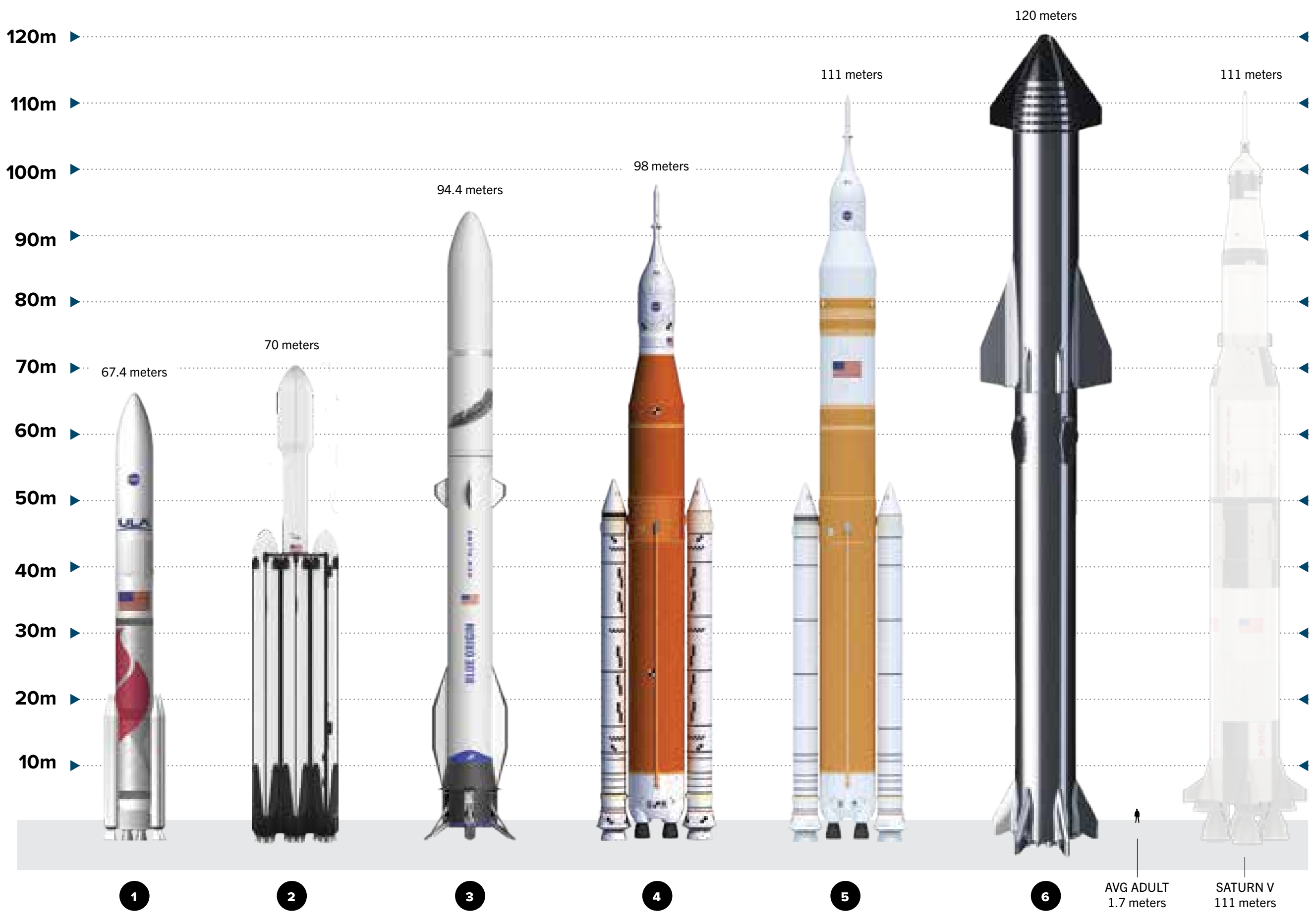
"In that budget, the only thing about human space flight that included NASA was production of a LOX [liquid oxygen] kerosene or LOX-rocket propellant engine" that would be suitable for powering a future heavy-lift rocket for crew transportation beyond LEO, recalls Bolden. Yet with no near-term plan to develop such a rocket, "NASA was essentially going to be relegated to the sideline."

In response to the fuming, the Obama administration quickly struck a compromise with Sens. Kay Bailey Hutchison, R-Texas, and Bill Nelson, D-Fla., the leaders of the Senate Commerce Committee that authorizes NASA programs and recommends spending levels: Hutchison and Nelson agreed to support the Commercial Crew program in the pending multiyear spending authorization bill, but the bill also committed NASA to developing a heavy-lift "Space Launch System" for human missions to Mars in the 2030s.

The next year, Hutchison was a featured speaker at the Capitol Hill press conference where NASA

A crowded field

A decade ago, when NASA conceived of the basic design for the Space Launch System, a line of government-owned expandable rockets for launches beyond low Earth orbit, none of the other rockets on this chart except the Falcon Heavy existed even in conceptual form, at least not publicly. Now there are multiple emerging players in the heavy-lift field. Here's how NASA's moon rocket designs stack up against them.



	OWNER/OPERATOR	FIRST FLIGHT	PAYLOAD CAPACITY TO THE MOON	PER LAUNCH COST
1 **Vulcan Centaur**	United Launch Alliance	2022	11 metric tons	Declined to say
2 **Falcon Heavy**	SpaceX	2018	16 metric tons	$150 million if fully expendable
3 **New Glenn**	Blue Origin	2022	Declined to say	Declined to say
4 **SLS Block 1**	NASA	"the end of" 2021 or "the first part of" 2022, per NASA	27 metric tons	~$1 billion
5 **SLS Block 1B**	NASA	2025	38 metric tons	To be determined
6 **Starship**	SpaceX	Soon, "pending only regulatory approval," per Elon Musk	100 metric tons, after refueling in LEO	Elon Musk has said "maybe" as low as $2 million

▲ Technicians from NASA and contractor Jacobs in June prepare to attach the SLS core stage for the inaugural flight to a crane, which will rotate the core stage and lower it vertically between two solid rocket boosters in High Bay 3 at the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida.

NASA

unveiled an early design of the first SLS rocket, the one that would be launched by the end of 2021 if all goes as planned. It was the SLS Block 1 design, the version that lacks the more powerful upper stage but could still send the 22.7-metric-ton Orion crew and service modules toward lunar orbit in a single launch ahead of a planned larger version, Block 1B.

The new program represented "a commitment that NASA" — Hutchison paused for emphasis — "NASA is going to lead the pack." The private rockets and spacecraft that would launch astronauts to ISS were a crucial capability, "but the leader is going to be the launch system that is being announced today."

It was a clear answer to the question about NASA's unique role: private companies could take over crew transportation to LEO, freeing up NASA to focus on more ambitious destinations.

The poster board drawings of SLS flanking the speakers certainly looked the part: Two massive solid rocket boosters flanked a white core stage reminiscent of the Saturn V (though NASA would later leave the core stage bright orange, the natural color of its insulation). The design was produced by an internal NASA working group that over the span of a year solicited feedback from space companies and considered dozens of designs and mission scenarios in which one or multiple rockets would launch astronauts in crew capsules, says AIAA Executive Director Dan Dumbacher, who co-chaired the working group as the then-deputy associate administrator for NASA's Exploration Systems Development division.

The group's findings answered the technical question about the necessity of a big rocket, concluding that launching a single Saturn V-class rocket was the most efficient option for delivering astronauts to within range of Mars or other deep space destinations, both in terms of cost and crew safety.

Dumbacher compares the strategy to the one employed by most first-year college students moving onto campus: "You pack up all your stuff and put it in mom's SUV or on one giant moving van. You don't spread it out across 20 smaller trucks."

This endeavor would be like no other in NASA's history, however. During development of the space shuttle fleet, the Saturn Vs and their predecessors, mission requirements alone had guided NASA designers — how much thrust was required to launch X number of astronauts in a Y-sized capsule to the desired destination. The working group was given a new constraint: Congress in the multiyear authorization act directed NASA to utilize existing contracts from the space shuttle and Constellation programs "to the extent practical."

At the time, that seemed like a good way to stay within the $3 billion annual spending limit for the program, which equated to an $18 billion total cost

A crane moves a Super Heavy prototype to the launch pad at SpaceX's Starbase facility in Texas. This Super Heavy has 29 Raptor engines, but Elon Musk has said future operational versions of the booster could be powered by up to 33 engines.

Elon Musk/SpaceX via Twitter

for the first SLS rocket, its Orion crew capsule, service module and launch pad upgrades. The estimate for all that would later grow to $38 billion, but NASA says that figure also includes the cost of test articles, facility upgrades and earcomponents for future rockets and capsules.

The group's recommendation, reflected in the SLS drawing unveiled at the 2011 press conference, was largely pieced together from disparate components — a Boeing-built core stage would be a brand new design, but powered by RS-25 engines from the shuttle orbiters; an upper stage derived from the blueprint for a Delta IV upper stage; and the Lockheed Martin-built Orion crew capsules originally designed to fly atop Ares rockets.

In some cases, the constraints limited the technical performance of SLS. For instance, NASA opted to modify and refurbish the 16 remaining RS-25s from the shuttle orbiters, even though their liquid hydrogen fuel is not as energy dense as the hydrocarbon RP-1 kerosene that powered the Saturn V, meaning there's less energy per unit of fuel. Also, the projected cost and time of developing the new core stages meant NASA had to delay development of the Block 1B variant, in which a more powerful upper stage could propel an additional 11 metric tons to the moon.

Converting existing hardware from the Constellation and shuttle programs afforded a political advantage "in selling the rocket and keeping it sold" to U.S. lawmakers writing NASA's annual budget, says Barnes, the former Boeing employee, who oversaw SLS design and early construction as program manager between 2013 and 2015. A former NASA official describes the trade-offs more bluntly: "Do you want a rocket program or not?"

What went wrong

By 2015, when Barnes retired, the original 2017 launch date had been bumped following the critical design review that cleared the contractors to begin flight hardware production in earnest. The new target of July 2018 amounted to a seven-month slip — not unheard in the history of NASA as program schedules are refined, but the SLS launch date kept moving to

▲ The liquid hydrogen tank for the core stage of the first Space Launch System after welding was finished at NASA's Michoud Assembly Facility in Louisiana.

NASA

the right. July 2018 became November 2018, which turned into December 2019, then June 2020. A new November 2020 target changed to mid-2021. Most recently, a November 2021 launch date has given way to NASA's current estimate of late 2021 or early 2022.

So what happened? There is no single answer.

Some point to a series of technical errors by NASA and its contractors. According to a March 2020 report by the NASA Office of Inspector General, the errors "collectively have resulted in $2 billion of cost overruns and increases and at least 2 years of schedule delays."

Boeing and NASA say some of these errors can be attributed to the challenges of first-time production, including the installation of custom tooling at NASA's Michoud Assembly Facility in Louisiana that took longer than expected.

The single biggest tooling error was the misalignment of the giant welder that assembles the aluminum barrels, domes and rings that comprise the core stage propellant tanks. After Boeing' subcontractor completed the cylindrical, cage-like welder in late 2014, technicians discovered the rails on which tank components are moved up and down via a metal ring were slightly lopsided, so the ring couldn't lift the core stage pieces to the full height of the 50-meter-tall welder.

NASA later found that the subcontractors didn't reinforce the floor at Michoud before installing the welder, so test hardware production had to be halted while the foundations were fortified and the tool rebuilt.

"When you start off and you haven't even finished the facility in which you're going to do the manufacturing and you find that you're delayed by two years because the tool's not right, that's not good," former NASA Administrator Bolden says. "You find that you have things that were not forecast or unforeseen and that's what brought us to where we are" with the program.

Compounding the technical errors is flat program funding, says analyst Dreier.

Consider the budget for the Saturn V rockets, which was $8 million (in 2020 dollars) in fiscal 1961, the first year of development. Congress steadily approved more money for Saturn V year after year through fiscal 1966, when funding peaked at $11.6 billion (in 2020 dollars). In contrast, during the first five years of the SLS program, Congress approved a $300 million increase between fiscal 2011 and fiscal 2016.

"They were told to do an Apollo-level rocket program with a 21st-century budget," says Dreier, meaning that when delays arose such as the one with the Michoud welder, there were no additional funds to keep the program on schedule.

And the nature of the cost-plus contracts under which SLS work is done means that NASA has paid

more than expected for rocket components. For instance, the $2.8 billion contract the agency awarded Boeing in 2011 for the first two core stages and preliminary work on the Block 1B upper stage had to be modified in early 2020. The new value is $9 billion.

Noone of Embedded Ventures pointed to the hierarchy of the SLS program as a reason why NASA and its contractors have struggled to stay within schedule and cost estimates. Unlike private launch companies including SpaceX that manufacture the majority of their rocket components in-house, SLS core stage prime contractor Boeing builds the stages at Michoud, Orion prime contractor Lockheed Martin constructs capsules in Colorado and at NASA's Kennedy Space Center in Florida, and so on. And each prime has its own network of subcontractors and suppliers, with parts coming from across the U.S. According to a NASA webpage of Artemis program suppliers, SLS in 2019 had suppliers in 41 of the 50 U.S. states, plus the District of Columbia.

"That is a very slow-paced machine," says Noone, who before co-founding his venture capital firm was a founder and the chief technology officer at California launch startup Relativity Space, whose approach of 3D printing their rockets cuts down on the number of required technicians and components.

In the case of SLS, he says, the multiple layers of subcontractors mean that reacting quickly to unexpected production errors or expediting work "is almost impossible."

But political support plays a role here as well, Dreier contends. The thousands of jobs across the country created by the program strengthens the rationale for Congress to continuously fund SLS. "It has, in a sense, a luxury of being so strongly supported that, in a way, inefficiency is not a bug but a feature of the system."

As with any program, there have also been factors out of NASA's control. Since 2011, a series of tropical storms and hurricanes have intermittently halted SLS core stage production at Michoud. In late August, for instance, Michoud was closed to guard against the strong winds and floods from Category 4 storm Hurricane Ida. Though no SLS hardware was damaged, officials told me the halt amounted to a three-week delay.

Like everyone, NASA has also had to contend with telework and social distancing restrictions prompted by the covid-19 pandemic. In August alone, 100 employees tested positive at Kennedy where technicians are assembling the first SLS, Nelson — now NASA's administrator — said during an early September media roundtable. He didn't say how many of those cases were people working on SLS.

▲ Each Space Launch System's forward skirt will connect the upper part of the rocket to the core stage and contains flight computers.

NASA

> "I would prefer that there exists in perpetuity an independent U.S. national capability to access and utilize space, irrespective of what commercial entities decide to do in addition. Not instead of, in addition."
>
> **— Former NASA Administrator Mike Griffin**

A tale of two rockets

Despite the delays, the first SLS rocket continues to take shape in the Vertical Assembly Building at Kennedy. The next major step was scheduled for early October, when technicians from NASA and its contractor Jacobs were to roll the Orion capsule over to the VAB and begin joining the two vehicles for final tests.

Several states over, in Texas, another monster rocket is coming to life. Standing at 120 meters tall, the first prototype of SpaceX's shiny stainless-steel Starship is even taller than the 98-meter-tall SLS Block 1 when both rockets are fully stacked.

And the differences don't end there. The SLS program has spent a decade and $19.6 billion. Along with constructing the hardware for the upcoming first SLS launch and some components for future rockets, the time and funds have been spent finalizing the Block 1 design and building and ground testing a handful of test articles including propellant tanks, as well as setting up the flow of operations for long-term production.

By contrast, over the span of nine years SpaceX designed an entirely new liquid-methane engine to power Starship and built at least the first 100 of these Raptor engines, constructed its Starbase facility in Texas and launched upper stage prototypes to low altitudes about 10 times. Most of the flights ended in spectacular explosions, but SpaceX says the rapid build-fly-repeat cycle has prepared the company to conduct the first orbital test flight of a Starship upper stage atop a Super Heavy booster before the end of this year, which means Starship could possibly beat SLS to space. However, that's pending completion of an FAA environmental assessment.

Not that NASA has anything against Starship. A Starship upper stage could ferry two astronauts from lunar orbit to the surface of the moon for a base-first landing in 2024, under a $2.9 million contract awarded by NASA in April. All but an initial $300 million remains in limbo because of ongoing protests and lawsuits from Blue Origin of Washington state, which also bid for the contract. NASA in August agreed to suspend Starship work until Nov. 1 while a lawsuit before the U.S. Court of Federal Claims is litigated, but none of this stops SpaceX from funding Starship development and testing on its own dime or pulling from the roughly $140 million NASA previously awarded the company under 2019 and 2020 study contracts.

Noone says the rapid progress of Starship is an indicator that the private launch market has matured to the point where NASA should transition from an operator to a customer, as it's done with the transport of astronauts to ISS.

"Objectively, SLS will be obsolete probably before it takes off from the pad," he says, so NASA should instead focus on what he calls "beyond launch" markets to advance technology that's too risky for private companies.

Others aren't so sure. Although a Starship could send more payload to orbits beyond LEO — 100 metric tons to the 27-metric ton capability of an SLS Block 1 — the design requires a more complicated method to transport that payload to the moon and deep space.

In the case of SLS, a cryogenic upper stage propelled by a single Aerojet Rocketdyne RL-10 engine provides the thrust for a translunar injection maneuver to send Orion on a trajectory to lunar orbit. In the Starship design, the rocket's upper stage would dock in LEO with a propellant depot and be refueled through a method SpaceX has not specified, then fire its six liquid methane Raptor engines for the trip to lunar orbit.

In a series of tweets in August, Musk said about eight "tanker flights" with additional Starships would be required to fill up the propellant depot, and these would be spaced out about six months before launching the lander.

SLS contractors in August touted the relative simplicity and proven design of their rocket during a

media roundtable at the Space Symposium in Colorado Springs, Colorado. The SLS design is better suited for deep space missions, Boeing's director of sales and marketing for deep space programs David Burks told me, because it can traverse "all the way to your destination in one launch."

He also contends that the Starship design won't be a one-size-fits-all vehicle. Consider robotic probes to the outer solar system: "It just makes no sense" to launch aboard a Starship with a 100-metric-ton capacity "if I'm taking 6 tons to Jupiter. I don't need that extra weight."

Even if Starship succeeds, one former NASA chief sees a compelling reason beyond technical performance for a government rocket program.

"We have private package and delivery services, but we still have a U.S. Postal Service for good reason," says Mike Griffin, NASA administrator between 2005 and 2009. "I would prefer that there exists in perpetuity an independent U.S. national capability to access and utilize space, irrespective of what commercial entities decide to do in addition. Not instead of, in addition."

Analyst Dreier agrees, but for a slightly different reason. Yes, relying on any single private company that could in theory go out of business would put the U.S. in a "precarious position," he says. More importantly, SpaceX's construction of an SLS-class rocket doesn't mean other companies will follow suit.

"Maybe we'll have this discussion again in 10 years, and at that point there will be a mature heavy-lift market with a range of vehicles that have proven reliability and financial stability, to the point where the government can bow out of this aspect of the marketplace."

Even if the first SLS launch ends in a fireball, it's unlikely the program would be canceled, contends Laura Forczyk of the Georgia consulting firm Astralytical. That could require a massive shift in NASA's human spaceflight program and the rocket's unwavering support from U.S. lawmakers.

"Nothing's going to happen this year or next year that will change anything," she predicts, given the massive amounts of hardware in various stages of production.

Case in point: NASA isn't going to wait and see if the first launch succeeds and is in the midst of finalizing the terms of a new contract with Boeing. The deliverables? Ten SLS core stages and eight of the powerful upper stages that would fly on the Block 1B variant. ★

▲ A Starship prototype was launched on a high-altitude flight test in May at SpaceX's Texas site. Among the companies developing heavy-lift rockets, SpaceX is the farthest ahead.

SpaceX


ELECTRO

FAITH IN BATTERIES

Whether electric rotorcraft will whisk passengers across town in the near future will depend largely on the performance limits of lithium-ion batteries. Will superior lithium batteries be ready in time to meet the urban air mobility demands? Keith Button went looking for answers.

BY KEITH BUTTON | buttonkeith@gmail.com

In one vision of urban air mobility, passengers will wait in line for their turn to ride across town in an electric rotorcraft, much like skiers waiting in line for the next gondola to take them up the mountain.

Ella Atkins, director of the Autonomous Aerospace Systems Lab at the University of Michigan and an avid skier, sees a problem with this vision. Most of the UAM concepts she's familiar with assume that the aircraft will be powered by lithium-ion batteries, but as matters stand today, those batteries will need to be recharged regularly, probably even after every flight. Once a UAM touches down, "there's going to be this whole: 'All right, get comfortable while we recharge or replace the batteries,'" Atkins says.

That's just one example of how Atkins and others want UAM entrepreneurs and developers to look realistically at their business plans in light of the pace of development of lithium-ion battery technology. Topping the list is energy density, the all-important ratio of electric power to a battery's weight or volume. If the ratio is too low, then the plane can't fly far enough with enough passengers to make the business case close.

Opinions vary, but some see a great reckoning coming, one that could leave UAM entrepreneurs scurrying to revamp their cost projections and business plans.

The UAM universe is so large that it's perhaps impossible to make one statement about power requirements that would hold true for every design. The World eVTOL Aircraft Directory counts 226 vertical takeoff and landing concepts with battery electric power or hybrid-electric power in which combustion engines contribute to the propulsion. That count doesn't include defunct designs, hover bikes or personal flying devices. For the larger designs, the Advanced Air Mobility Reality Index compiled by Phoenix-based SMG Consulting identifies the 20 UAM manufacturers who SMG believes are most likely to bring their aircraft into service for passenger flight. To make the list, a company's design must target at least 227 kilograms of payload capacity, which typically equates to four to six passengers. Currently on the list are 14 electric and six hybrid-electric designs.

Battery predictions

Battery scientist Venkat Viswanathan, a Carnegie Mellon University assistant professor, is one of those who is upbeat about battery technology. By 2025, he predicts, UAM aircraft designers will have plenty of lithium-ion designs to choose, each offering enough peak power and a high enough energy density for the aircraft to meet goals for range and speed. Viswanathan and 24M Technologies Inc., a Cambridge, Massachusetts, battery developer, are developing batter-

ies for a UAM company that's asked them not to disclose its identity.

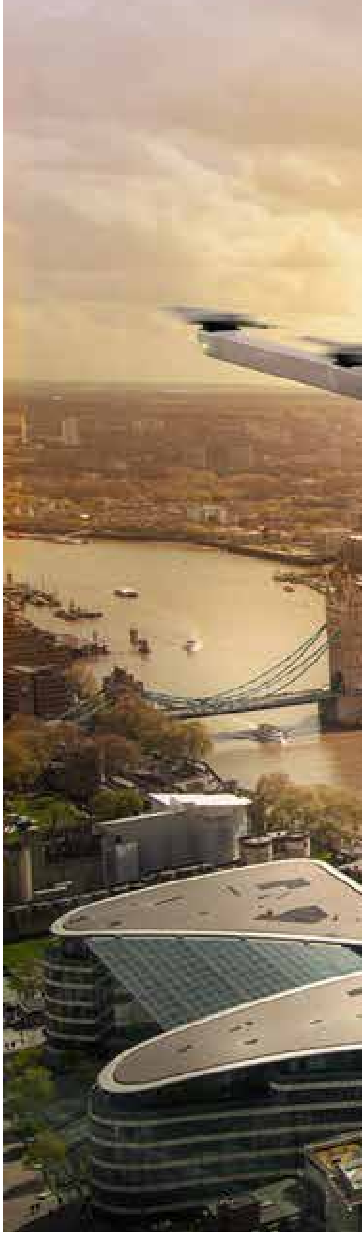
In Viswanathan's view, 400 watt-hours per kilogram at the cell level is the "magic number" for energy density that will unlock the potential for most electric-powered UAM designs in the 2025 time frame. Viswanathan says he has helped develop battery cells — separate from the 24M Technologies work — at close to the 400 mark. With more engineering and design work, thousands of such cells could be assembled to form a battery with an energy density of 250 Wh/kg. The battery for a Tesla Model 3, a benchmark for current technology because it is by far the most produced and analyzed electric car battery, falls well short: An energy density of 250 to 270 Wh/kg at the cell level and about 170 Wh/kg for the battery itself, Viswanathan says. Today's aviation batteries flown in scaled-down UAM prototype aircraft have energy densities that are better than Tesla 3 batteries at the cell level — 280 to 300 Wh/kg — but only about the same energy densities for the batteries — 160 to 180 Wh/kg. That's because each aircraft has multiple batteries, which are less efficient than having one battery per vehicle, and they require more battery packaging than in electric cars to meet stricter aviation safety requirements.

Perhaps Viswanathan and others will prove to be right, but the question for UAM entrepreneurs is how

▲ Pipistrel says the battery for its Alpha Electro can be charged in less than an hour or replaced within minutes. The Slovenia-based company's Velis Electro aircraft is the first European Union Aviation Safety Agency type-certified electric aircraft for day visual flight rules operations.

Pipistrel

> "You can make a given airplane design look better than it is by limiting some of the worst-case scenarios that it needs to handle. I care about how you handle off-nominals and emergencies; that's really the only thing I care about."
>
> — Gur Kimchi, co-founder of Amazon Prime Air



closely they should tailor their plans to such best-case scenarios. Some startups are counting on the necessary energy densities being available by a certain year, along with FAA certification in that year, without accounting for the fact that the FAA will require them to freeze their designs before beginning the certification process that will likely take four or five years, says Glenn McDonald, a principal at AeroDynamic Advisory, an aerospace consulting firm in Ann Arbor, Michigan. And even aside from the battery projection issue, nearly every UAM entrepreneur is failing to factor into their business plans the yearslong commitment required by the FAA or its European equivalent, the European Union Aviation Safety Agency.

"I haven't seen any real timeline out there that has a reasonable development and certification timeline associated with it," McDonald says.

Making unrealistic assumptions about future batteries can also drive up costs, says Gur Kimchi, who co-founded Amazon Prime Air, the proposed drone delivery service, and now serves on the board of Ascent Aerosystems, a Massachusetts drone builder. If the batteries aren't already available and the UAM company is counting on a unique aerospace battery to be developed just for its aircraft, then the vehicle is probably going to be too expensive for UAM passengers to fly in it, he says. Also, the UAM designer can't know for sure the energy densities of the batteries, how much peak power they will provide, whether enough batteries will be available for purchase, their cost and how many recharge cycles they'll have. If the batteries can't provide 1,000 to 1,200 recharges, then the UAM operator will have to buy new batteries too frequently for the economics to make sense. A UAM operations model developed by AeroDynamic Advisory estimates that batteries will be capable of providing energy density of 200 to 300 Wh/kg by 2025 at a cost of $400 per kilowatt hour of capacity, which is about four times the cost per kilowatt hour of a current Tesla 3 battery. That would put the total cost of a 2025 UAM battery at $40,000 to $80,000.

▲ Eve Urban Air Mobility Solutions, a subsidiary of Brazil's Embraer SA, plans to sell 200 electric vertical takeoff and landing aircraft to Halo, which provides helicopter and pilot services in the United Kingdom and United States. Pictured is an artist's rendering of Eve's eVTOL.

Embraer

Also critical is the amount of energy that a battery can retain as it ages. An electric car with an 8-year-old battery might lose 20% of its original 500-kilometer range, but the remaining 400-kilometer range is still valuable to the owner, because there are numerous destinations within that range. But for an electric aircraft battery, the same 20% loss would leave the aircraft with an effective range of zero, because so much energy must be expended on takeoff that the battery could not deliver enough electricity for the almost equally energy-hungry landing phase. "Pretty much all aviation batteries today for the UAM applications are currently limited by their inability to land once the battery ages," Viswanathan says.

Fire safety will also affect the future battery energy density numbers. Battery developers don't know yet what aircraft safety regulators will require for UAM battery packaging that prevents thermal runaway — a fire in one cell that spreads to other cells. The packaging adds to the weight of the battery, reducing its energy density. Current aircraft lithium battery packaging requirements are so strict that those that provide backup power on airliners have an energy density of only 64 Wh/kg, partly because the cells are separated by polymer barriers and each battery is encased in a stainless-steel box. UAM designers and their battery developers see the current regulations as an overreaction to the Boeing Dreamliner 787 lithium battery fires in 2013, and they are betting that regulators will allow UAM batteries to have more lenient standards, Viswanathan says.

Cooling the UAM batteries could also add weight to the battery designs. The batteries designed for UAM aircraft rely on passive cooling from air flow, but they may need liquid cooling piped through the batteries, like the glycol cooling loops for Tesla batteries, Viswanathan says.

Budgeting battery energy

Batteries will be able to provide only a limited amount of energy during the course of a UAM flight, even with the energy densities predicted in a few years. That means analysts are paying close attention to predictions by UAM designers of how much time their aircraft will spend taking off, the most energy-depleting portion of the flight. For David Wyatt, an eVTOL analyst at IDTechEx, a research firm in the United Kingdom, the electric UAM aircraft that can demonstrate with prototype flights that they can take off without spending a lot of energy will have the best chances to be deployed by the end of the decade. Those aircraft will have more flexibility to handle longer flights and emergency situations.

In their attempts to accommodate limited battery energy densities, some UAM aircraft developers have made unrealistic assumptions in budgeting power and time for the vertical takeoff and landing portions of flights, Kimchi says. By understating the length of time in these power-draining flight periods and underestimating adverse flight conditions due to things like high temperatures, bad weather, wind gusts and aborted landings, they're not providing an accurate depiction of their proposed flight operations.

"You can make a given airplane design look better than it is by limiting some of the worst-case scenarios that it needs to handle," Kimchi says. "I care about how you handle off-nominals and emergencies; that's really the only thing I care about." The designer can't just tell the certification agency that under certain flight conditions, "Well, I'm sorry, I can't land."

To cope with range uncertainties, regulators might need to require eVTOL aircraft to operate out of conventional airports whose runways would provide some margin for error. An aircraft that ran out of power toward the end of a flight or that needed to make an emergency return, could at least reach the end of a runway. Right now, most UAM developers plan to fly in and out of vertiports constructed on the ground or the tops of buildings.

If an aircraft can't operate in adverse conditions, its dispatch reliability — the percentage of time it flies without delays or cancellations — goes down. And if your dispatch reliability dips below 90%, customers will abandon you, Kimchi says.

Airplane safety certification will require that UAM aircraft always maintain a minimum battery energy reserve to reach a nearby airport, though it seems likely that the FAA and EASA will be open to a shorter time than the 20 minutes now required for commercial air taxi service or charter flights, says Martha Neubauer, a senior analyst at AeroDynamic Advisory in Ann Arbor.

Batteries could make matters easier for UAM developers in one respect: The distributed propulsion designs of electric UAM aircraft provide some safety advantages over traditional designs, Viswanathan says. The UAM designs typically allocate one battery for every two rotors, so if a battery fails, the aircraft can continue flying.

Adapting business plans

UAM manufacturers and operators could be prompted to adapt their business models once they discover the limitations of their batteries in real-world operational scenarios. The companies that raise enough capital from investors will get their aircraft certified and bring their aircraft to market, even if the aircraft don't make sense economically, Kimchi predicts.

But a good business case can be made even when battery limitations dictate short flights, Atkins says. "I suspect that those who have the financial means to fly regularly on a helicopter are going to be all over an eVTOL alternative because it's going to be quieter; it's going to be cooler, sleeker, fun."

Some companies might modify their business plans by switching from electric-only designs to battery-plus-combustion-engine hybrid designs for added propulsion and generation to lengthen their flights. But doing so will erase one of the main UAM selling points, Wyatt says. "To sell a concept which still results in CO_2 emissions is probably not quite as desirable," he says. "When it comes to the kind of environmental-credentials side of things, everything is going zero emissions and lower emissions."

And some companies — Piasecki Aircraft of Essington, Pennsylvania, and Russia-based Bartini Aero, for example — are developing electric UAM aircraft powered by hydrogen fuel cells, which in theory would avoid the range and performance problems that battery-only-powered designs present.

Hybrid-electric UAM designs — those generating electric power with combustion engines and those generating electric power with hydrogen fuel cells — would be giving up one of their main cost advantages: running only on electricity instead of paying for aviation fuel or hydrogen, Wyatt says. "Suddenly you're paying for fuel, and the fuel overhead becomes a part of that calculation as well," he says. "That's going to be an issue for operators as well, whether they can make a viable business while they're still having to pay high fuel prices."

In the future, aerospace engineers might reflect on today's lithium-ion batteries and their shortcomings like engineers now look at the star-shaped piston engines that powered World War II-era planes. Tomorrow's energy storage solution might be a better lithium-ion battery design or something else entirely.

"We created things like radial engines that were all the rage," Atkins says. "When we go to an air show, we want to hear them. But now we look back at that and we're like: 'You know, these things sounded cool, but they were really inefficient and unreliable. But they were useful, and they got the jobs done.'" ★

AIAA IS ASSESSING THE PATH AHEAD IN THE

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TOP-LINE FINDINGS

- Outlook on the aerospace industry is cautiously optimistic, varying widely between the United States and other countries. The mood in space is 82% positive, while only 75% positive in aviation.
- Public policy priorities for aerospace are clear – maintain stable funding, invest in research, develop technology infrastructure, and develop an educated workforce pipeline.
- Professionals would recommend a career in aerospace to a young person today.
- COVID-19 impacts will continue as the aviation sector recovers.
- Cybersecurity tops the list of challenges facing aerospace and defense.
- Employees expect a demonstrated commitment to DEI from their employers – which they feel is not always being met.

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- Sustainability Through Diversification
- Workforce Sustainability

SPEAKER HIGHLIGHTS

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Chief Scientist, U.S. Air Force

Laura McGill
Deputy Laboratories Director and Chief Technology Officer for Nuclear Deterrence, Sandia National Laboratories

Pam Melroy
Deputy Administrator, NASA

Brendan Reed
Director, Airport Planning & Environmental Affairs, San Diego Airport Authority

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

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

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Calendar

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2021			
4 Oct–10 Nov	Design of Spacecraft & Systems Engineering Course	ONLINE (learning.aiaa.org)	
6–8 Oct	Understanding Cybersecurity in the Space Domain Course	ONLINE (learning.aiaa.org)	
7–28 Oct	Turbulence Modeling for Aerodynamic Flows Course	ONLINE (learning.aiaa.org)	
12 Oct–4 Nov	Hypersonic Propulsion Concepts: Design, Control, Operation, and Testing Course	ONLINE (learning.aiaa.org)	
19 Oct–4 Nov	Space Architecture: Designing a Lunar Habitation System Course	ONLINE (learning.aiaa.org)	
25–29 Oct*	72nd International Astronautical Congress	Dubai, UAE	
26–28 Oct*	International Symposium on Unmanned Systems and the Defense Industry	Washington, DC, & ONLINE (http://isudef.org/workshop)	
26 Oct–18 Nov	Aviation Cybersecurity Course	ONLINE (learning.aiaa.org)	
8–10 & 15–17 Nov	ASCEND Powered by AIAA	Las Vegas, NV, & ONLINE	30 Mar 21
15–17 Nov	AIAA International Space Planes and Hypersonic Systems & Technologies Conference	Las Vegas, NV, & ONLINE	30 Mar 21
29–30 Nov	Australian International Aerospace Congress & Region VII Student Conference	ONLINE	15 Sep 21
2022			
3–7 Jan	AIAA SciTech Forum	San Diego, CA, & ONLINE	1 Jun 21
7 Jan	3rd AIAA Geometry and Mesh Generation Workshop (GMGW-3)	San Diego, CA	
7 Jan	4th AIAA CFD High Lift Prediction Workshop (HLPW-4)	San Diego, CA	
8 Jan	Additive Manufacturing: Structural and Material Optimization Course	San Diego, CA	
8 Jan	Computational Aeroelasticity Course	San Diego, CA	
8 Jan	Hypersonics: Test and Evaluation Course	San Diego, CA	
8 Jan	Technical Writing Essentials for Engineers Course	San Diego, CA	
8–9 Jan	Agile Systems Engineering Course	San Diego, CA	
8–9 Jan	Aircraft and Rotorcraft System Identification Engineering Methods Course	San Diego, CA	
8–9 Jan	Design of Electrified Propulsion Aircraft Course	San Diego, CA	
8–9 Jan	Missile Guidance Course	San Diego, CA	
8–9 Jan	OpenFOAM CFD Foundations Course	San Diego, CA	

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.).

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2022			
8–9 Jan	Spacecraft Design, Development, and Operations Course	San Diego, CA	
8–9 Jan	1st AIAA High Fidelity CFD Workshop	San Diego, CA	
18 Feb–8 Apr	Design of Experiments: Improved Experimental Methods in Aerospace Testing Course	ONLINE (learning.aiaa.org)	
28 Feb–11 Mar	Fundamentals of Python Programming with Libraries for Aerospace Engineers Course	ONLINE (learning.aiaa.org)	
5–12 Mar*	2022 IEEE Aerospace Conference	Big Sky, MT (aeroconf.org)	
25–26 Mar	AIAA Region III Student Conference	West Lafayette, IN	27 Jan 22
25–26 Mar	AIAA Region IV Student Conference	San Antonio, TX	31 Jan 22
1–3 Apr	AIAA Region VI Student Conference	Merced, CA	5 Feb 22
4–6 Apr*	3rd IAA Conference on Space Situational Awareness (ICSSA)	Madrid (http://reg.conferences.dce.ufl.edu/ICSSA)	
19–21 Apr	AIAA DEFENSE Forum	Laurel, MD	19 Oct 21
21–24 Apr	AIAA Design/Build/Fly	Wichita, KS	
26 Apr	AIAA Fellows Induction Ceremony and Dinner	Arlington, VA	
27 Apr	AIAA Aerospace Spotlight Awards Gala	Washington, DC	
3–5 May*	6th CEAS Conference on Guidance, Navigation and Control (EuroGNC)	Berlin, Germany (eurognc2022.dglr.de)	31 Oct 21
16–19 May*	26th Aerodynamic Decelerator Systems Technology Conference and Seminar (ADSTCS)	Balma, France (https://earthlydynamics.com/adst-2022)	
30 May–1 Jun*	29th Saint Petersburg International Conference on Integrated Navigation Systems	Saint Petersburg, Russia	
21–24 Jun*	ICNPAA 2021: Mathematical Problems in Engineering, Aerospace and Sciences	Prague, Czech Republic (icnpaa.com)	
25–26 Jun	7th AIAA Drag Prediction Workshop ("DPW-VII: Expanding the Envelope")	Chicago, IL	
26 Jun	2nd AIAA Workshop for Multifidelity Modeling in Support of Design & Uncertainty Quantification	Chicago, IL	
27 Jun–1 Jul	AIAA AVIATION Forum	Chicago, IL	10 Nov 21
16–24 Jul*	44th Scientific Assembly of the Committee on Space Research and Associate Events (COSPAR)	Athens, Greece (cospar-assembly.org)	11 Feb 22
4–9 Sep*	33rd Congress of the International Council of the Aeronautical Sciences (ICAS 2022)	Stockholm, Sweden (icas2022.com)	10 Feb 22
18–22 Sep*	73rd International Astronautical Congress	Paris, France (iac2022.org)	
24–26 Oct	ASCEND Powered by AIAA	Las Vegas, NV	

AIAA Continuing Education offerings

**Meetings cosponsored by AIAA. Cosponsorship forms can be found at aiaa.org/events-learning/exhibit-sponsorship/co-sponsorship-opportunities.*

Recognizing Top Achievements – An AIAA Tradition

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

AIAA acknowledges the following individuals who were recognized between July and September 2021.

Presented at the AIAA AVIATION Forum 2–6 August 2021, Virtual

AIAA Service Awards

2021 AIAA Sustained Service Award

Willem A. Anemaat
DAR Corporation
For extensive service to AIAA through work on technical committees, national awards, publications, and conferences and forums.

Terry J. Burress
Lockheed Martin Corporation
For continuous and exemplary service to the AIAA South Central Region and the Modeling and Simulation Technical Committee, including strengthening the membership and the technical excellence of the Institute and its committees in both formal and informal leadership roles.

David W. Levy
Sierra Nevada Corporation
For sustained service as AIAA Wichita Section and Aircraft Design Technical Committee Chair, Design/Build/Fly Competition Contest Administrator, and Drag Prediction Workshop Organizing Committee.

Dimitri N. Mavris
Georgia Institute of Technology
For 40 years of continuous meritorious service to AIAA in technical, honors and awards, publications, and international activities.

AIAA Technical Awards

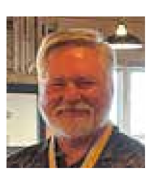
2020 AIAA Aerodynamics Award

Mark D. Maughmer
Pennsylvania State University
For foundational developments in airfoil and wing design, advancement of novel airfoil configurations, and contributions to rotorcraft aeromechanics

2021 AIAA Aeroacoustics Award

Ephraim J. Gutmark
University of Cincinnati
For his pioneering and outstanding contributions to the application of aeroacoustics practice to achieve quiet aircraft engines and new understanding of voice production and treatments.

2021 AIAA Aerodynamics Award



Scott A. Morton
DoD HPCMP
For a career devoted to extending the application of CFD to challenging unsteady aerodynamic phenomena, such as transonic flutter, complex vortical flowfields, and maneuvering flight.

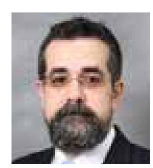
2021 AIAA Aircraft Design Award

Pipistrel Velis Electro
Accepting the award: Paolo Romagnolli and Tine Tomažič, Ajdovščina, Slovenia
For being the world's first certified electric aircraft leading the marketplace in a new era of green aircraft design and technology.

2021 AIAA Fluid Dynamics Award

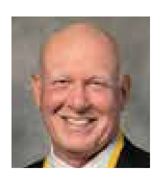
Charles Meneveau
Johns Hopkins University
For advancing both the theoretical and practical understanding of turbulence through groundbreaking modeling techniques and applications of large-eddy simulation.

2021 AIAA Ground Testing Award



Guillermo Paniagua
Purdue University
For significant contributions in aerothermal high-speed flow instrumentation and novel wind tunnels to support the aerospace industry, outstanding service to AIAA, dissemination, and mentorship.

2021 AIAA Losey Atmospheric Sciences Award



Harold E. (Gene) Addy, Jr.
NASA Glenn Research Center
For exceptional achievements and leadership in advancing aviation safety and the state of art of atmospheric research through experimental ice accretion and aerodynamic studies.

2021 AIAA Otto Winzen Lifetime Achievement Award

Rodger E. Farley
Farley Flight Aerospace LLC
In recognition of a lifetime of achievements in applying aerospace mechanics to the dynamic response of aerospace vehicles from spacecraft to aircraft and to balloons.

2021 AIAA Plasmadynamics and Lasers Award

David L. Carroll
CU Aerospace LLC
For scientific enhancement and innovation of high energy lasers and plasma-driven devices, entrepreneurial aerospace leadership, and education of scientist engineers.

2021 AIAA Thermophysics Award

Zhuomin Zhang
Georgia Institute of Technology
In recognition of outstanding contributions to microscale and nanoscale thermophysics and the understanding of interactions between thermal radiation and micro/nanostructured materials.

Presented at the 2021 AIAA Propulsion and Energy Forum, 9–11 August 2021, Virtual

2021 AIAA Aerospace Power Systems Award

Robert J. Walters
Space Vehicles Directorate, Air Force Research Laboratory
For significant technical contributions and leadership in the area of space photovoltaic technology development and solar cell radiation damage research.

2021 AIAA Air Breathing Propulsion Award

J. Philip Drummond, PE
NASA Langley Research Center
For his pioneering contributions to high speed air-breathing propulsion, his leadership in aerospace engineering, and for his continuous contributions to AIAA.

2021 AIAA Energy Systems Award

Kai Hong Luo
University College London
For groundbreaking contributions to multiscale multiphysics modeling and simulation that have transformed energy system analysis, prediction, design and optimization through research, innovation, education, and leadership.

2021 AIAA Propellants & Combustion Award

Yiguang Ju
Princeton University
Outstanding contributions in studies of near-limit combustion, plasma assisted combustion, micro combustion, and cool flames.

2021 AIAA Wyld Propulsion Award

Stephen D. Heister
Purdue University
For continuous leadership in advancing rocket propulsion engineering through state-of-the-art computational and experimental research and decades of mentorship of students.

Presented at the AIAA DEFENSE Forum, 14–16 September 2021, Laurel, Maryland

2021 AIAA Wright Brothers Lecture in Aeronautics

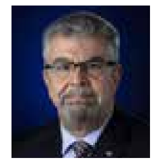
Walter H. Rutledge
CENTRA Technology Inc., a PAE Company
Lecture: "Hypersonics for National Security: Conventional Prompt Strike"

2021 AIAA Missile Systems Award

Ralph H. Klestadt
Raytheon Missiles & Defense
For over four decades of technical contributions and outstanding leadership in the advancement of missile systems technologies.

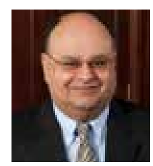
Presented at the 26th Ka and Broadband Communications Conference and the 38th International Communications Satellite Systems Conference (ICSSC), 27–30 September 2021

2020 AIAA Aerospace Communications Award



Badri A. Younes
NASA Headquarters
For lifetime accomplishments and outstanding leadership in the advancement of space communications and for promoting interoperability between commercial and space agency networks.

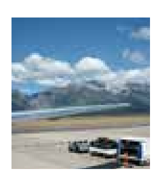
2021 AIAA Aerospace Communications Award



Pradman P. Kaul
Hughes Network Systems, LLC
For technical and management leadership of the creation and development of the Very Small Aperture Terminal (VSAT) satellite communications industry.

Presented at the 2021 AAAE National Airports Conference, 26–28 September 2021

2021 AIAA/AAE/ACC Jay Hollingsworth Speas Airport Award



Jackson Hole Airport Board
Jackson, Wyoming
For the continuous prioritization of sustainability at the airport to protect the environment and support a resilient future for the community.

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

MAKING AN IMPACT Digital Avionics Technical Committee Increases Scholarship Funding

The AIAA Digital Avionics Technical Committee is committed to helping university students earn their aerospace degree through a generous donation to the AIAA Foundation! The technical committee has gifted $50,000 to the Foundation to increase the award amount of the four undergraduate scholarships the technical committee currently funds from $2,000 to $3,000 each, and to endow a fifth undergraduate scholarship. The new scholarship, the Denise Ponchak Digital Avionics Scholarship, is intended for a non-U.S. person attending a non-U.S. college or university. The AIAA Foundation is grateful for this gift that will help support future aerospace professionals.

The AIAA Foundation awards more than $75,000 each year in undergraduate scholarships and graduate awards. The next application portal will be open 1 October through 31 January. To learn more, visit aiaa.org/get-involved/students-educators/scholarships-graduate-awards.

"Being recognized by AIAA is an incredible honor that motivates me to pursue knowledge and excellence in aerospace engineering even further. I will use this scholarship to fund my education, taking more technical courses relevant to aircraft design and safety before starting my career as an aerospace engineer." *– Elton Shinji Okuma Haychiguti, 2021 Dr. James Rankin Digital Avionics Scholarship Winner*

"Thanks to the Dr. Amy R. Prichett Digital Avionics Scholarship, I will be able to pursue my dream of becoming a successful Aerospace Engineer. I am thankful for having been chosen for this award, and can't wait to keep gaining technical and soft skills in aerospace." *– Laura Morejon Ramirez, 2020 Dr. Amy Prichett Digital Avionics Scholarship Winner*

Help us to continue supporting students with a gift to the AIAA Foundation. Donate today and make an impact please visit aiaa.org/foundation or contact Alex D'Imperio, alexandrad@aiaa.org.

AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award

CALL FOR NOMINATIONS

Nominations are currently being accepted for the 2022 **AIAA/AAAE/ACC Jay Hollingsworth Speas Airport Award**. The recipient will receive a certificate and a $7,500 cash prize.

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

For nomination forms, please visit **aiaa.org/SpeasAward**. Presentation of the award will be made at the AAAE/ACC Planning, Design, and Construction Symposium, scheduled for February 2022.

DEADLINE: 1 November 2021
CONTACT: AIAA Honors and Awards Program at awards@aiaa.org

aiaa.org/SpeasAward

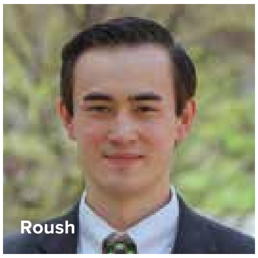
This award is jointly sponsored by AIAA, AAAE, and ACC.

AIAA SHAPING THE FUTURE OF AEROSPACE

AAAE THE AMERICAN ASSOCIATION OF AIRPORT EXECUTIVES

ACC AIRPORT CONSULTANTS COUNCIL

AIAA Announces Winner of Prestigious Abe M. Zarem Graduate Award for Distinguished Achievement in Aeronautics


Roush


Mavris

Karl Roush has won the AIAA Zarem Graduate Student Award for Distinguished Achievement in Aeronautics for his paper "Designing for Security: A Cybersecurity Introduction for Aerospace." Roush has been invited to present his paper at the 33rd Congress of the International Council of the Aeronautical Sciences (ICAS 2022), 4–9 September 2022, in Stockholm, Sweden.

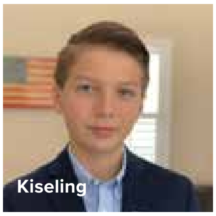
Roush, who completed his undergraduate degree in Aerospace Engineering at the Georgia Institute of Technology in 2020, remained to pursue a M.S. Aerospace Engineering. As a Department of Energy Gas Turbine Fellow, he has worked on small gas turbine developments for the Air Force Research Laboratory. Not just limited to fixed wing, Roush also worked as a Project Component Engineering intern at Aerojet Rocketdyne on the RL10 rocket engine. His graduate work with Aerospace Systems Design Laboratory (ASDL) focuses on smart technologies for the FAA, modeling of space-based ISR architectures, and hypersonic reconnaissance vehicle design exploration. His technical interest in data analytics has led him to develop ML/AI solutions for companies including Wells Fargo and NVIDIA. An active AIAA member, Roush serves as the Georgia Tech Student Branch graduate liaison.

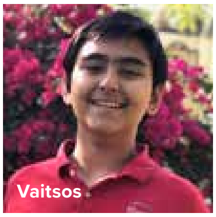
"It is my honor to accept the Abe M. Zarem Graduate Award and I cannot wait to meet my fellow AIAA members at both AIAA SciTech and ICAS," Roush said. "Many thanks to my mentor, Dr. Dimitri Mavris, as well as my ASDL colleagues for their continued support. It is my hope that this inspires others to learn more about cybersecurity in AE!"

Roush's faculty advisor, Dimitri Mavris, is the Director of the Aerospace Systems Design Laboratory at the Georgia Institute of Technology. He is the Boeing Chaired Professor of Advanced Aerospace Systems Analysis in Georgia Tech's School of Aerospace Engineering, Regents Professor, and an S.P. Langley NIA Distinguished Professor. He also serves as the Executive Director of Georgia Tech's Professional Master's Applied Systems Engineering program. He is an AIAA Fellow and a Fellow of the Royal Aeronautical Society.

AIAA Honorary Fellow Dr. Abe Zarem, founder and managing director of Frontier Associates, established the Abe M. Zarem Graduate Awards for Distinguished Achievement to annually recognize graduate students in aeronautics and astronautics who have demonstrated outstanding scholarship in their field.

Unique Science Experiments on the Moon — SSTC 2021 Middle School Essay Contest


Kiseling


Vaitsos

The AIAA Space Systems Technical Committee's (SSTC) annual middle school essay contest continues to improve its commitment to directly inspire students and local sections. Each year, additional local sections start parallel contests to feed into selection of national winners awarded by the SSTC.

The 2021 essay topic was "Describe science experiments you can conduct on the lunar surface that are unique to our moon." Seventh and eighth grade students were asked to participate. This year, various AIAA sections submitted official entries to the contest, including Antelope Valley, Cape Canaveral, Hampton Roads, Long Island, Palm Beach, Rocky Mountain, Southwest Texas, and Vandenberg. For each grade, there were first-, second-, and third-place winners, which included $125, $75, and $50 awards for the students, respectively. The six students also received a one-year student membership with AIAA.

The first-place winner for 8th grade was **Paul Kiseling** (and teacher Shawna Christenson) from Palm Beach Gardens, FL (AIAA Palm Beach Section). The second-place winner for 8th grade was **Mikayla Palmer** from Great Falls, MT (AIAA Rocky Mountain Section). The third-place winner for 8th grade is **Chrislaina Anderson** from Santa Maria, CA (AIAA Vandenberg Section).

The first-place winner for 7th grade is **Argyrios Dean Vaitsos** (and teacher Shawna Christenson) from Palm Beach, FL (AIAA Palm Beach Section). The second-place winner for 7th grade is **Gemma Braza** from Colorado Springs, CO (AIAA Rocky Mountain Section). The third-place winner for 7th grade is **Nish Keer** from Levittown, NY (AIAA Long Island Section).

All 2021 winning essays can be found on the *Aerospace America* website (https://aerospaceamerica.aiaa.org/bulletin/october-2021-aiaa-bulletin). The topic for 2022 is "This is a placeholder topic for now. The topic is TBD." If you, your school, or section is interested in participating in the 2022 contest, please contact Anthony Shao-Berkery (ant.shao@gmail.com), Erica Rodgers (erica.rodgers@nasa.gov), or your local section for more details.

Dr. Scott Horton, winner of the 2021 AIAA Aerodynamics Award, was also recognized at the dinner. Left to right: Dr. Ryan Sherrill, NW FL section chair; Dr. Morton; and Dr. Angela Diggs, NW FL vice section chair.

Northwest Florida Section Honors Members

By Ryan Sherrill, AIAA Northwest Florida Section Chair

The AIAA Northwest Florida Section honored two professional members and three educator associates during our section's end-of-the-year banquet. **Dr. Daniel Reasor** won Professional of the Year for his extraordinary dedication, creativity, and leadership in the development of modeling and simulation capabilities to advance hypersonic airframes. **Dr. John Fay** won the Achievement Award in recognition for his sustained and outstanding contribution to STEM Outreach, measured by volunteer hours, miles driven to rural schools, and emails sent to university sections.

The section also honored **David Williams** of Bethlehem High School in Holmes County, FL, who started one of the first AIAA high school branches. Additionally, he sponsors multiple programs such as the SeaPerch underwater rover competition, the Drone Swarm Programming competition, Higher Orbits, and the Great American Paper Plane Contest. **Marian Gilmore**, a teacher at Silver Sands, a Special Day School in Okaloosa County, FL, was honored for her work in joining the Civil Air Patrol's Aerospace Connections in Education (ACE) program and winning National ACE School of the Year in 2020-2021. During the weeks leading up to the Perseverance's landing on Mars, Ms. Gilmore invited and virtually hosted former NASA Astronaut Don Thomas to talk to all the classes about the upcoming rover landing on Mars, sponsored a virtual STEM night, and invited Janet Ivey of Janet's Planet and President of Explore Mars, who led them virtually through making lunar landers. **Alyson McCullough**, a teacher at Hilliard Middle Senior High School in Nassau County, FL, was recognized for writing grant proposals for which she received over $15,000 in funding to take a two-acre field and turn it into a poultry and fruit tree farm and made three-quarter-acre rotation beds to teach students about crop sustainability. Using the Florida State Standards for Agriculture, students are prepared to take the Agriculture Education Services & Technology certification test, which then will allow students to gain access to job training programs and complete their five credit hours toward Florida Bright Futures Gold Seal Scholarships.

AIAA On the Road

AIAA staff is back on the road visiting sections, student branches, and corporate members. In August, AIAA Executive Director Dan Dumbacher met with the **Twin Cities Section** and **University of Minnesota Student Branch**. Some of the staff also attended the 36th Space Symposium, meeting with many corporate members and members of the **Rocky Mountain Section**.

In September AIAA Vice President of Community and Partner Engagement Merrie Scott and Regions & Sections Program Manager Lindsay Mitchell traveled to Philadelphia to meet with volunteer leaders from the **Greater Philadelphia Section**, the **Drexel University Student Branch**, and the **Villanova University Student Branch**.

AIAA Drexel University Student Branch Chair Kate Hazaveh and Vice-Chair Yanni Tsetskos met with Lindsay Mitchell to discuss upcoming engagement strategies

Membership Nominations Open for AIAA Technical Committees & Integration and Outreach Committees

The Technical Activities Division (TAD) and Integration and Outreach Division (IOD) work diligently with their committee chairs to maintain a reasonable balance in appropriate representation to the field from industry, research, education, and government and the specialties covered in the specific TC/IOC scopes. TAD and IOD encourage the nomination of young professionals (those individuals 35 years and younger). Committees have a 50-person maximum unless approval is granted to exceed that limit. Nominees selected for membership who are not AIAA members in good standing must become members or renew their membership within 45 days of start of the membership term (1 May–30 April).

If you currently serve on a TC/IOC, you will automatically be considered for the 2022/2023 membership term. Nominations are submitted online. The nomination form can be found on the AIAA website at aiaa.org, under My AIAA, Nominations and Voting, Technical Committee Online Nomination. Nominations are due by 1 November 2021.

Information about the committees can be found at Integration and Outreach Committees aiaa.org/integration-and-outreach-division-committees Technical Committees aiaa.org/technical-committees

Obituaries

AIAA Senior Member Wasz Died in June 2019

Glenn Wasz, age 88, passed away on 21 June 2019.

Wasz earned a bachelor's degree in mechanical engineering from the University of Notre Dame, followed by a master's degree in the same field from the University of Southern California. He served two years with the U.S. Army during the Korean War era.

Wasc settled in California, earned his professional engineering license, and spent most of his career with TRW. He advanced the understanding of how to design and test space vehicles capable of surviving high shock and random vibration environments, and was active in the Institute of Environmental Sciences and the American Society of Mechanical Engineers.

AIAA Associate Fellow Gagnier Died in February

Thomas R. Gagnier died 12 February at the age of 86.

Gagnier received his B.S. in Civil Engineering from the University of Detroit in 1957 and M.S. in Contract and Acquisition Management from the Florida Institute of Technology in 1992. He worked for Martin Marietta over 35 years in Orlando, Colorado Springs, and Oak Ridge, where he retired as the Director of Advanced Programs. Gagnier was instrumental in the expansion of the IR&D programs as well as guiding the divisional growth of Contracts and Data Management in Orlando. During his tenure at Oak Ridge National Labs, Gagnier successfully developed environmental technology markets for Martin Marietta. He twice received Martin Marietta's highest corporate level award, the Jefferson Cup, for his superior performance to Martin Marietta in 1977 and 1982.

Gagnier's passion was the education and mentoring of engineering students. Gagnier was the director of the AIAA Southeastern Regional Student Conference from 1978 to 1988. He also served for many years with the AIAA ABET accreditation team, the AIAA Academic Affairs Committees (now Committee on Higher Education), and the AIAA Student Activities Committee. He received both a Special Service Citation (1988) and a Sustained Service Award (2003) for his volunteer work with AIAA. He also was honored with the 1986 AIAA Distinguished Service Award "for more than twenty years of continuous and dedicated service to the Institute and community for his contributions to Education, Public Policy, and Technical Committees."

AIAA Senior Member Young Died in August

Laurence R. Young, the Apollo Program Professor Emeritus of Astronautics and professor of health sciences and technology at MIT, died on 4 August. He was 85.

Young received a B.A. from Amherst College in 1957; a certificate in applied mathematics from the Sorbonne, Paris, as a French Government Fellow in 1958; B.S. and M.S. degrees in electrical engineering and an Sc.D. in instrumentation from MIT in 1962.

Young joined the faculty in the Department of Aeronautics and Astronautics at MIT in 1962. There, he co-founded the Man-Vehicle Laboratory (now the Human-Systems Laboratory) with Y.T. Li to conduct his research on the visual and vestibular systems, visual-vestibular interaction, flight simulation, space motion sickness, and manual control and displays. He was widely regarded for his pioneering role in the field of bioastronautics, focusing on the human factors of spaceflight. Young helped launched the Harvard-MIT Program in Health Sciences and Technology (HST) doctoral program in bioastronautics.

Young also consulted with NASA Marshall Spaceflight Center on the Apollo project and later became a qualified payload specialist for the U.S. space shuttle's Spacelab biological laboratory in 1993. While he never flew a space mission, he served as backup crew on Spacelab Life Sciences-2 (STS-58) and was principal or co-investigator on seven shuttle missions conducting human orientation experiments.

Over the years he also held visiting professor positions, including at the Swiss Federal Institute of Technology, the Conservatoire des Arts et Metiers in Paris, the Universite de Provence, and Stanford University. Young was the founding director of the National Space Biomedical Research Institute (1997–2001) and also served as director of the Massachusetts Space Grant Consortium.

Young received extensive recognition for his contributions, including election to the National Academy of Engineering, the Institute of Medicine of the National Academy of Sciences, and the International Academy of Astronautics. He held fellowships with the Institute of Electrical and Electronics Engineers, the Biomedical Engineering Society, the American Institute of Medical and Biological Engineering, and the Explorers Club. In 1982, Young received the AIAA Dryden Lectureship in Research, and he was among the recipients recognized with the 1992 AIAA Jeffries Aerospace Medicine and Life Sciences Research Award "for outstanding contributions to space biology and medicine as a principal investigator on the Spacelab Life Sciences 1 mission." In 1995, NASA recognized his achievements with a Space Act Award for his development of an expert system for astronauts. In 1998, he also received the prestigious Koetser Foundation Prize in Zurich for his contributions to neuroscience. In 2013, he received the Pioneer Award from the National Space Biomedical Research Institute. In 2018, he received the AIAA de Florez Award for Flight Simulation, and the Aerospace Medical Association's Professional Excellence Award for Lifetime Contributions.

Outside of his career as an engineer, Young was an avid skier, which led him to become active in ski injury research. He was a director of the International Society for Skiing Safety and chaired the Ski Injury Statistics Subcommittee of the American Society for Testing and Materials Committee on Snow Skiing before being elected committee chair in 1987. He received a Best Research Paper Award from the American Academy of Orthopedic Surgeons.

AIAA Announces Section Awards Winners

AIAA has announced its 2020–2021 section awards winners. The section awards honor particularly notable achievements made by member sections in a range of activities that help fulfill the Institute's mission. Section awards are given annually in five categories based on the size of each section's membership. Each winning section receives a certificate and a cash award. The award period covered is 1 June 2020–31 May 2021. The Institute believes that vital, active sections are essential to its success.

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

Very Small: First Place (tie): Delaware, Daniel Nice (Northrop Grumman Corporation), section chair; **First Place (tie): Vandenberg,** Michelle Itzel (Axient), section chair; **Third Place (tie): Adelaide,** Patrick Neumann (Neumann Space), section chair; **Third Place (tie): Wisconsin**, Michael Carkin (Sierra Nevada Corporation), section chair

Small: First Place: Northwest Florida, Ryan Sherrill, section chair; **Second Place: Utah,** Catherine Beck (Northrop Grumman), section chair; **Third Place (tie): Long Island**, David Paris, section chair; **Third Place (tie): Palm Beach**, Randy Parsley (Pratt & Whitney), section chair

Medium: First Place, Tucson, Michelle Rouch (Artwork by Rouch), section chair; **Second Place: Phoenix,** Michael Mackowski**,** section chair; **Third Place: Greater Philadelphia,** Jonathan Moore (Lockheed Martin Corporation), section chair

Large: First Place (tie): St. Louis, Mark Kammeyer (The Boeing Company), section chair; **First Place (tie): San Diego**, Joel Perez (Solar Turbines), section chair; **Third Place: Orange County,** James Martin, section chair

Very Large: First Place: Los Angeles-Las Vegas, Chandrashekhar Sonwane (Aerojet Rocketdyne) and Jeffrey Puschell (Raytheon Intelligence and Space), section chairs; **Second Place: Greater Huntsville,** Nishanth Reddy Goli, section chair; **Third Place: Rocky Mountain,** Stacey DeFore (Lockeed Martin Space Systems)

The **Communications Award** is presented to sections that have developed and implemented an outstanding communications outreach program. Winning criteria include level of complexity, timeliness, and variety of methods of communications, as well as frequency, format, and content of the communication outreach. The winners are:

Very Small: First Place: Delaware, Zachary Gent (Northrop Grumman), membership officer; **Second Place: Vandenberg,** Steve Boelhouwer (Mantech International), newsletter editor; **Third Place: Adelaide**, Patrick Neumann (Neumann Space), section chair

Small: First Place: Northwest Florida, Ryan Sherrill, section chair; **Second Place: Utah,** Ryan Clawson, section secretary; **Third Place: Wichita**, Balaji Chandrasekaran Kartikeyan (Wichita State University), section secretary; Alexis Fitzpatrick

Medium: First Place: Tucson, Michelle Rouch (Artwork by Rouch), section chair; **Second Place: Greater Philadelphia,** Jonathan Moore (Lockheed Martin Corporation), section chair; **Third Place: Phoenix,** Michael Mackowski, section chair

Large: First Place: Northern Ohio, Edmond Wong (NASA Glenn Research Center), communications officer; **Second Place: Atlanta,** Neil Sutherland (Delta Air Lines), section chair; **Third Place: San Diego,** Stevie Jacobson (General Atomics Aeronautical Systems), section secretary

Very Large: First Place: Los Angeles-Las Vegas, Ken Lui (Ken's Consulting), program officer, **and** Jeffrey Puschell (Raytheon Intelligence and Space), section chair; **Second Place: Greater**

Huntsville, Nishanth Reddy Goli, section chair, and Alex Vasenkov (Sunergolab), publicity officer; **Third Place: Hampton Roads,** John Lin (NASA Langley Research Center) and Lee Mears (NASA Langley Research Center), newsletter editors

The **Membership Award** is presented to sections that have supported their membership by planning and implementing effective recruitment and retention campaigns. The winners are:

Very Small: First Place: Vandenberg, Michelle Itzel (Axient), section chair; **Second Place: Delaware,** Christina Larson (Northrop Grumman), communications officer; **Third Place: Adelaide**, Patrick Neumann (Neumann Space), section chair

Small: First Place: Northwest Florida, Ryan Sherrill, section chair; **Second Place: Utah**, Michael Miller (Northrop Gruman), membership officer; **Third Place: Wichita**, Wilfredo Cortez (Department of Defense)

Medium: First Place: Tucson, Rajka Corder (Raytheon Missile Systems), membership officer; **Second Place: Greater Philadelphia**, Jonathan Moore (Lockheed Martin Corporation), section chair; **Third Place, Antelope Valley**, Chris Coyne (U.S. Air Force), publicity officer

Large: First Place: St. Louis, Alex Friedman (The Boeing Company), membership officer; **Second Place (tie): Orange County**, Robert Welge (Robert's Engineering Development), membership officer; **Second Place (tie): San Diego,** Joel Perez (Solar Turbines), section chair

Very Large: First Place: Hampton Roads, Richard Winski (NASA Langley Research Center), membership offier; **Second Place: Los Angeles-Las Vegas,** Aldo Martinez Martinez (The Boeing Company), membership officer; **Third Place: Greater Huntsville,** Paul Palies (University of Tennessee Space Institute), membership officer

The **Public Policy Award** is presented for stimulating public awareness of the needs of aerospace research and development, particularly on the part of government representatives, and for education section members about the value of public policy activities. The winners are:

Very Small: First Place: Delaware, Di Ena Davis, public policy officer; **Second Place: Vandenberg**, Michelle Itzel (Axient), public policy officer and section chair; **Third Place, Adelaide**, Patrick Neumann (Neumann Space), section chair

Small: First Place: Palm Beach, Kevin Simmons (BLUECUBE Aerospace), public policy officer; **Second Place: Utah,** Charlie Vono, public policy officer; **Third Place: Northwest Florida,** Michael Kelton (U.S. Air Force), membership officer

Medium: First Place: Tucson, Robert Tagtmeyer (Raytheon Missiles & Defense), public policy officer; **Second Place (tie): Phoenix,** Brianna Grembowski (Northrop Grumman Space Systems), public policy officer; **Second Place (tie): Greater Philadelphia**, Nicholas Altobelli (Lockheed Martin Corporation), communications officer

Large: First Place: Orange County, Kamal Shweyk (Boeing Commercial Airplanes), public policy officer; **Second Place (tie): San Diego,** Cesar Martin (U.S. Navy), public policy officer; **Second Place (tie): Niagara Frontier**, Walter Gordon, section chair

Very Large: First Place (tie): Greater Huntsville, Naveen Vetcha (ERC Incorporated), public policy officer; **First Place (tie): Rocky Mountain,** Joe Rice (Lockheed Martin Space Systems), public policy officer; **Third Place: Los Angeles-Las Vegas,** Jordan Chilcott, public policy officer

The **STEM K–12 Award** is presented to sections that have developed and implemented an outstanding STEM K–12 outreach program that provides quality education resources for K–12 teachers in the STEM subject areas. The winners are:

Very Small: First Place: Vandenberg, Thomas Stevens (U.S. Air Force) STEM K12 outreach officer; **Second Place (tie): Wisconsin**, Todd Treichel (Sierra Nevada Corporation), STEM K-12 outreach officer; **Second Place (tie): Delaware,** Kelly Storrs (Northrop Grumman); STEM K-12 outreach officer

Small: First Place: Northwest Florida, Judith Sherrill, STEM K-12 outreach officer; **Second Place: Palm Beach,** Shawna Christenson, STEM K–12 outreach officer; **Third Place: Wichita,** Minisa Childers (Aeronautix)

Medium: First Place: Tucson, Michelle Rouch (Artwork by Rouch), section chair officer; **Second Place: Antelope Valley**, Robert Jensen (Sierra Lobo, Inc), STEM K-12 officer and Jason Lechniak (NASA Armstrong Flight Research Center), section chair

Large: First Place: Cape Canaveral, Melissa Sleeper (Storm Grove Middle School/School District of Indian River), STEM K–12 outreach officer; **Second Place: St. Louis**; Jackie Blumer (Greenville Jr. High School), STEM K-12 outreach officer; **Third Place: Orange County,** Ed Rocha, Binay Pandey and Janet Koepke, STEM K–12 outreach officers

Very Large: First Place: Los Angeles-Las Vegas, Khushbu Patel, STEM K-12 outreach officer; **Second Place (tie): Rocky Mountain,** Susan Jannsen (United Launch Alliance), STEM K-12 outreach officer; **Second Place (tie): Hampton Roads,** Karen Berger (NASA Langley Research Center) and Amanda Chou (NASA Langley Research Center), STEM K-12 outreach officers; **Second Place (tie): Greater Huntsville**, Ragini Acharya (University of Tennessee Space Institute), STEM K-12 officer

The **Section-Student Branch Partnership Award** recognizes the most effective and innovative collaboration between the professional section members and student branch members.

Very Small: First Place: Adelaide, Patrick Neumann (Neumann Space), section chair; **Second Place: Vandenberg**, Evan Agarwal, university liaison; **Third Place: Wisconsin**, Michael Carkin (Sierra Nevada Corporation), section chair

Small: First Place: **Northwest Florida**, John Fay (Torch Technologies), education officer; **Second Place: Twin Cities**, Kristen Gerzina (Northrop Grumman), section chair; **Third Place: Utah**, Michael Stevens (Northrop Grumman), programs officer

Medium: **First Place**: **Tucson,** Alexis Hepburn (Raytheon Missiles and Space), career and workforce development officer, and Rob Michalak (Paragon Space Development); **Second Place; Greater Philadelphia**, Jonathan Moore (Lockheed Martin Corporation), section chair; **Third Place: Phoenix**, Michael Mackowski, section chair

Large: First Place: San Diego, Joel Perez (Solar Turbines), section chair; **Second Place, Albuquerque**, Svetlana Poroseva (University of New Mexico), university liaison; **Third Place, Atlanta**, Neil Sutherland (Delta Air Lines), section chair, and Aaron Harcrow, membership officer; **St. Louis**, Charles Svoboda (The Boeing Company), education officer

Very Large: First Place, Los Angeles-Las Vegas, Khusbu Patel, STEM K-12 officer; **Second Place: Rocky Mountain**, Dan Scantland; **Third Place: New England,** Umanga Balasuriya (Charles River Analytics), university liaison

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

Very Small: First Place: Adelaide, Mahdy Alhameed (University of Adelaide), young professional officer; **Second Place: Wisconsin**, Michael Carkin (Sierra Nevada Corporation), section chair; **Third Place: Delaware**, Taylor Coleman, young professional officer

Small: First Place: Northwest Florida, Alexandra Straub (U.S. Air Force), young professional officer; **Second Place (tie): Savannah,** Alessandra Carno, young professional officer**; Second Place (tie): Utah**, Justin Wettstein (Northrop Grumman), young professional officer

Medium: First Place: **Tucson**, Michael Hotto (Raytheon Technologies), young professional officer; **Second Place: Antelope Valley,** Joseph Piotrowski (NASA Armstrong Flight Research Center), young professional officer; **Third Place: Greater Philadelphia**, Jonathan Moore (Lockheed Martin Corporation), section chair

Large: First Place: St. Louis, Stephen Clark (The Boeing Company), young professional officer; **Second Place: Orange County,** Bradley Williams (Tyvak Nano-Satellite Systems), young professional officer; **Third Place (tie): Niagara Frontier,** Walter Gordon, section chair officer; **Third Place (tie): Northern Ohio**, Dan Londrico, young professional officer

Very Large: First Place: Los Angeles-Las Vegas: Brett Cornick, Aakash Nareshkumar (RoviSys) and Ken Lui (Ken's Consulting), young professional section officers; **Second Place: Rocky Mountain,** Alexandra Dukes (Lockheed Martin Space Systems) and Tyler Walston, young professional officers; **Third Place: Hampton Roads**, Michelle Lynde (NASA Langley Research Center) and Brett Hiller (NASA Langley Research Center), young professional section officers

The **Outstanding Activity Award** allows the Institute to acknowledge sections that held an outstanding activity deserving of additional recognition. The winners are:

Very Small: Wisconsin, Michael Carkin, section chair. **Rocket Science for Future Engineers.** This program focused on female K-12 students from the underserved areas of Wisconsin education. Hands-on demonstrations, visual aids, and real-life spaceflight examples provided a foundation for bringing these students face-to-face with space-related science, designed hardware, technology, and their potential benefits with the hope of increasing interest in aerospace- and space-related fields that lead to study at the university level followed by an aerospace career. Teams built a high-powered rocket, made use of the established AIAA rocket science curriculum (workbooks, and RockSim simulation software), and built a high-powered rocket for the purpose of launch of a small research payload. Areas such as chemisty, computer-aided design, problem-solving, electronics, and graphic design were included in this initiative.

Small: **Utah**, Catherine Beck, section chair. **Wasatch Aerospace and Systems Engineering Mini-Conference**. The AIAA Utah Section and the INCOSE Wasatch Chapter partnered to create the inaugural "Wasatch Aerospace and Systems Engineering Mini-Conference," a two-day event that highlighted the work of industry and academic professionals, students, and retirees. The theme of the conference, "Celebrating the Creativity of Engineers," highlighted the interconnectivity that exists between creativity and engineering. There were 21 presentations given over the two days by speakers from across the country, with cash prizes in each category. Giveaways were sent to all conference attendees that highlighted local artists and businesses as well as corporate sponsors. Attendees could work on an optional technical competition – either a coding challenge titled "Remote Controls" or a Lego challenge titled "W.F.H. (Winning From Home)." There was a "Geeks Who Drink" Trivia Night on Thursday night including door prizes from local artists. All of this was completed via Zoom due to the COVID-19 pandemic. There were approximately 65 total attendees.

Medium: **Tucson**, Michelle Rouch, section chair. **Celebrating the 50th Anniversary of the Apollo 14 Mission**. In 2020 many organizations had to cancel their in-person Apollo 13 50th anniversary celebration. The Apollo 14 50th anniversary lunar mission occurred 13 January–9 February 1971. On 8 February 2021, on the eve of the Apollo 14 splashdown, section members and nonmembers had a section meeting with special guest, Jack Roosa, who shared stories about his father, Stuart Roosa, Command Module pilot during the Apollo 14 mission. Although it was virtual, attendees were offered prizes of gift cards, free admission for the members' next field trip to Pima Air & Space Museum, and other door prizes.

Large: **Northern Ohio**, Christine Pastor-Barsi, section chair. **Young Aerospace Visionaries Contest**. To ignite or strengthen interest in STEM, particularly as it relates to the field of aerospace, students were invited to use their imaginations to push the boundaries of what is possible in the future to create a visual depiction of their futuristic vision of air or space travel technologies. Each visual submission was accompanied by a written essay describing the student's vision, providing rationale for it, and giving some background about their interest in the field of aerospace. There were different grade ranges for project judging. A total of 26 applications were received from 7 different counties, 11 different schools and 1 home school student. Awards for the top three submissions included monetary awards, admission to the Great Lakes Science Center, and the option to attend the section's Annual Picnic for engagement with section members and recognition.

Honorable Mention: Niagara Frontier, Walter Gordon, section chair. An Inside Look at the F-35A. Captain Kristin "Beo" Wolfe, commander and demonstration pilot for the U.S. Air Force F-35A Demonstration Team, gave an inside look at this unmatched fifth generation fighter. The F-35A Lightning II is without question the most capable multirole fighter aircraft in the world, combining stealth, sensor fusion, and unmatched situational awareness.

Very Large: **Rocky Mountain**, Stacey DeFore, section chair. **"A Night Amongst the Stars" 2020 Honors & Awards Recognition Drive-In**. The Rocky Mountain Section invited guests to honor awardees, Fellows, and Associate Fellows in the first-ever Drive-In Awards. The program was broadcast on a 26' LED screen with audio delivered via a designated FM radio frequency. Immediately following the program, guest were treated to a showing of "Apollo 13." All necessary precautions for social distancing were followed according to Colorado state guidelines. Awardees drove up to the front of the stage and were celebrated by the audience through headlight flashing and car horns.

Honorable Mention: Greater Huntsville, Nishanth Reddy Goli, section chair**. Alabama Quiz Bowl State Championships.** In support of the State Champioships for the Alabama Academic Quiz Bowl, the section hosted the two large, traditionally in-person tournaments – one for middle school and one for high school – through Zoom sessions and Buzzin.live, an online buzzer system. The section and other partners sponsored the tournaments by providing support in the form of funding, volunteers, technical expertise, and even a tournament director to handle all the logistics and coordination associated with live, online tournaments.

Tenure-Track Faculty in the Department of Aerospace Engineering

The Department of Aerospace Engineering at The Pennsylvania State University invites nominations and applications for a tenure-track faculty position starting in Fall 2022. The position is intended for the rank of Assistant Professor, although exceptional applicants at more senior ranks may also be considered.

Outstanding candidates working in all subject areas relevant to aerospace engineering will be considered. The department is seeking new faculty to both bolster its current areas of strength (including aerodynamics, aeroacoustics, avionics, autonomy, materials and structures, and rotorcraft) and to grow its reach into new areas of expertise (including novel vehicle design and expanded areas in space systems). Applicants should articulate their plans to setup a research program attracting outside research sponsorship, contributing to the aerospace industry, and resulting in published research findings. Further, applicants should describe how they will collaborate with the disciplinary strengths already in place within the department in support of cross-disciplinary collaborative research and in support of the department's undergraduate and graduate programs.

The Department of Aerospace Engineering at Penn State is strongly committed to our educational mission. Successful candidates should demonstrate interest in teaching undergraduate and graduate courses.

Applicants must have an earned doctorate in aerospace engineering or a related field by the start date. Responses received before October 23, 2021 are assured full consideration, but the search will remain open until the position is filled. Applicants should submit electronically a single pdf file that contains a cover letter, a CV, summary of their activities and interests in research, in teaching, and in diversity, equity and inclusion, and the names and contact information for at least three references.

Employment with the University will require successful completion of background check(s) in accordance with University policies.

The Department of Aerospace Engineering enjoys an excellent international reputation in aeronautics and astronautics. The department currently has 19 full-time tenured/tenure-track faculty members, more than 250 juniors and seniors, and more than 120 graduate students. Annual research expenditures exceed $6 million.

Penn State at University Park is a land-grant institution located within the beautiful Appalachian Mountains of central Pennsylvania. State College and nearby communities within Centre County are home to roughly 100,000 people, including over 40,000 students, and offer a rich variety of cultural, recreational, educational, and athletic activities. State College is a wonderful community in which to raise a family and has an excellent public school system.

We especially encourage applications from individuals of diverse backgrounds, as the department seeks to grow in the diversity of its faculty. Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to minorities, females, veterans, disabled individuals, and other protected groups.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability or protected veteran status. If you are unable to use our online application process due to an impairment or disability, please contact HR Services at 814-865-1473.

Apply online at **https://apptrkr.com/2477807**

CAMPUS SECURITY CRIME STATISTICS: For more about safety at Penn State, and to review the Annual Security Report which contains information about crime statistics and other safety and security matters, please go to http://www.police.psu.edu/clery/, which will also provide you with detail on how to request a hard copy of the Annual Security Report.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability or protected veteran status.

Massachusetts Institute of Technology

Department of Aeronautics and Astronautics Tenure-Track Faculty Position

The Massachusetts Institute of Technology (MIT) Department of Aeronautics and Astronautics invites applications for tenure-track faculty positions with a start date of July 1, 2022 or a mutually agreeable date thereafter. The department is conducting a search for exceptional candidates in any discipline related to aerospace engineering, broadly defined, though particular interests are in: (i) the interaction of humans and autonomy, (ii) sustainable aviation, especially aero-engine technologies or environmental monitoring, and (iii) human exploration of space.

We are seeking highly qualified candidates with a commitment to research and education. Faculty duties include teaching at the graduate and undergraduate levels, advising students, conducting original scholarly research, developing course materials at the graduate and undergraduate levels, and service to the Institute and the profession.

Candidates should hold a doctoral degree in a field related to aerospace engineering or another relevant science or engineering field by the beginning of employment. The search is for candidates to be hired at the assistant professor level; under special circumstances, however, a senior faculty appointment is possible, commensurate with experience.

Applications must include a cover letter, curriculum vitae, 2–3 page statement of research and teaching interests and goals, as well as names and contact information of at least three individuals who will provide letters of recommendation. In addition, candidates should provide a statement regarding their views on diversity, inclusion, and belonging, including past and current contributions as well as their vision and plans for the future in these areas. Applicants with backgrounds outside aerospace should describe how a substantial part of their work will apply to aerospace problems. Applications must be submitted as a pdf at https://faculty-searches.mit.edu/aeroastro/register.tcl. Letters of recommendation must be submitted directly by the recommenders at https://faculty-searches.mit.edu/letters/.

To ensure full consideration, complete applications should be received by 1 December 2021. Applications will be considered complete only when both the applicant materials and at least three letters of recommendations are received.

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

For more information on the MIT Department of Aeronautics and Astronautics, please visit http://aeroastro.mit.edu/. Applicants may find reading our strategic plan helpful in preparing their application (https://aeroastro.mit.edu/about/strategic-plan). Questions can be directed to faculty search chair Prof. Julie Shah at julie_a_shah@csail.mit.edu.

MIT is an equal employment opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, sex, sexual orientation, gender identity, religion, disability, age, genetic information, veteran status, ancestry, or national or ethnic origin. MIT's full policy on Nondiscrimination can be found at the following: https://policies.mit.edu/policies-procedures/90-relations-and-responsibilities-within-mit-community/92-nondiscrimination.

http://web.mit.edu

Aerospace Engineering and Mechanics Aerospace Structures and Advanced Materials

UNIVERSITY OF MINNESOTA

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The Department of Aerospace Engineering and Mechanics (AEM) seeks to fill one tenure-track faculty position in modern experimental methods in Aerospace Structures and Advanced Materials (ASAM). Current research in the AEM department includes the development of nanoscale mechanics (molecular dynamics, lattice statics, quasicontinuum method, applied quantum mechanics) and continuum mechanics (phase transformations, phase field models, micromagnetics, stability and bifurcation) for the understanding and discovery of advanced materials and structures. The AEM department has close ties with on-campus multidisciplinary centers, and convenient access to outstanding shared experimental and computational facilities, such as the Minnesota Nano Center, the Characterization Facility, the Center for Magnetic Resonance Research, and the Minnesota Supercomputing Institute. Information about the department is available at https://cse.umn.edu/aem

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

The intent is to hire at the assistant professor rank. It is anticipated that the appointment will begin fall 2022.

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

To be considered for this position, candidates must apply on-line through Interfolio at: **http://apply.interfolio.com/94000**

This position requires that you attach the following documents as PDFs : 1) cover letter, 2) detailed resume, 3) names and contact information of three references, 4) a statement of teaching interests, and, 5) a statement of research interests. The teaching and research statements should include prior or proposed contributions to diversity, equity and inclusion.

Application Deadline: The initial screening of applications will begin on November 1, 2021; applications will be accepted until the position is filled.

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CONTINUED FROM PAGE 64

sign my re-enlistment papers, he said, "Mark my words: If you leave the military you will amount to nothing and will be living in a cardboard box under a bridge." Words from a fellow defender gave me the courage to say goodbye: "Don't let anyone's opinion of you become your reality."

There will surely be trying moments for the refugees, perhaps nothing like in Afghanistan. I moved to Daytona Beach, Florida, hoping to attend Embry-Riddle Aeronautical University, but couldn't get the financial aid to line up. Working as a security guard 16 hours a day except for Sundays, I found myself broke, in debt and literally foraging for food in dumpsters. My commander's prophecy seemed to be coming true. I went back home to my mother and stepfather's apartment in Caracas to regroup. I made another run at Embry-Riddle, and this time I went as an aerospace engineering student at the university's campus in Prescott, Arizona. I proceeded to graduate school at the University of Colorado, and into professional astrodynamics at NASA's Jet Propulsion Laboratory in California. This was followed by the Air Force Research Laboratory on Maui, which is where I truly came to understand what it means to be an American.

I was named a member of the United States delegation to the United Nations Committee On Peaceful Uses of Outer Space, in Vienna. I was in awe as I sat in a large room with the other international delegations. My parents were no longer living, but how I wished for them to see me. Looking around that room, I realized that the Chinese delegation looked very obviously Chinese. The Indian delegation, similarly. This continued until I looked to my left and right across the United States delegation. What does an American look like? Our last names were Latino, Asian, European, African and so on. We were proud of our heritages and yet we spoke with one voice: E Pluribus Unum. Within me, I heard Ray Charles singing "America the Beautiful." I realized what it means to be American and how important a role our country plays in the world. We are humanity's experiment in diversity as a form of strength, a strength derived by continually striving for perfect liberty. As flawed as America is, we walk with a courage that is best defined as the absence of paralysis in the presence of fear.

Anyone from around the globe is free to criticize America and we must be accountable to the world, but the world has a vested interest in seeing America succeed. Afghans will be part of our success. They will discover that America is not a land of perfect fairness or equity or even justice, but it is a land where a beautiful life can become a reality. ★

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1921

Oct. 5 U.S. Army Maj. Gen. Mason Patrick is appointed chief of the Army Air Service, replacing the first chief, Maj. Gen. Charles Menoher. Having commanded U.S. army aviation forces in Europe during World War I, Patrick brings practical experience to the job, which includes a general downsizing of the existing force while securing the Air Service's role in the postwar U.S. military. David Baker, **Flight and Flying, A Chronology**, p. 140.

Oct. 18 U.S. Army Brig. Gen. William "Billy" Mitchell pilots a Curtiss R6 to a world speed record of 358.82 kph over a 1 kilometer course at Mount Clemens in Michigan. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 14.

During October 1921 In recognition of the effectiveness of air power, the British government sends units of the Royal Air Force to Iraq to replace existing British and Indian Army troops. The RAF proves effective in policing the country. David Baker, **Flight and Flying, A Chronology**, pp. 140-141.

1946

Oct. 1 The U.S. Naval Air Missile Test Center at Point Mugu, California, is established for conducting tests of Navy guided missiles and components. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 55.

1 **Oct. 2** Chance Vought's first jet plane, the XF6U-1 Pirate fighter, makes its first test flight at Muroc Dry Lake, California. The XF6U-1 is designed as a carrier-based fighter for the U.S. Navy and is equipped with a single Westinghouse J34 turbojet engine. Thirty of the pudgy straight-winged aircraft are built before the Navy cancels the project. Gordon Swanborough and Peter Bowers, **United States Naval Aircraft Since 1911** , p. 473.

Oct. 6 The U.S. Air Force Boeing B-29 Superfortress "Pacusan Dreamboat," piloted by Col. C.S. Irvine, is flown on the first nonstop Hawaii-to-Egypt flight over the magnetic North Pole, a distance of 17,500 kilometers. David Baker, **Flight and Flying, A Chronology**, p. 312.

Oct. 7 W. Stuart Symington, U.S. assistant secretary of war, and top generals issue a directive to end duplication in U.S. missile programs and naming the Army Air Forces as the logical branch to manage the Army's missile program. J. Neufeld, **Ballistic Missiles in the United States Air Force, 1945-1960**, pp. 22-23.

Oct. 11 Bell test pilot Chalmers Goodlin flies the Bell XS-1 No. 2 on its first glide flight at Muroc, California. This is one of three XS-1s contracted by the National Advisory Committee for Aeronautics, NASA's predecessor, and the U.S. Air Force to study transonic flight. XS-1 No. 1 will break the sound barrier the next year, with Capt. Chuck Yeager at the controls. Jay Miller, **The X-Planes: X-1 to X-45**, p. 27.

Oct. 27 The U.S. Navy's nonrigid XM-1 airship with 20,000-cubic-meter capacity sets the world's endurance record without refueling for all types of aircraft, staying aloft for 170 hours and 18 minutes. The XM-1, carrying a crew of 13 under Lt. H.R. Watson, takes off on this date from Lakehurst, New Jersey, and cruises south over the Atlantic coast and Gulf of Mexico, landing at Glynco, Georgia, Naval Airship Station. **The Aeroplane**, Nov. 22, 1946, p. 610.

During October 1946 U.S. Army Ordnance initiates the development of Project Bumper, the testing of a two-stage liquid-fuel rocket using a captured German V-2 as the first stage and a U.S. Jet Propulsion Laboratory-made WAC-Corporal sounding rocket. E.M. Emme, ed., **Aeronautics and Astronautics, 1915-60**, p. 55.

1971

2 **Oct. 4** Lunokhod 1, the first self-propelled lunar vehicle, stops operating after 321 days on the moon. The eight-wheeled rover stops transmitting photos and making soil analyses to Earth when its isotope heat reserves are exhausted during its 11th lunar night. The vehicle arrived on the moon on the Luna 17 lunar probe on Nov. 17, 1970, traveled 10,540 meters and produced 500 panoramas, 20,000 TV pictures and 35 chemical analyses of the lunar soil. **New York Times**, Oct. 10, 1971, p. 68; **Aviation Week**, Oct. 18, 1971, p. 17.

Oct. 5 The Daniel and Florence Guggenheim Space Theater at the American Museum's Hayden Planetarium in New York City is dedicated. NASA, **Aeronautics and Astronautics, 1971**, p. 279.

3 **Oct. 6** NASA test pilots complete two flights of the TF-8A, a modified Vought F-8 jet aircraft with a supercritical wing, from the Flight Research Center at Edwards Air Force Base in California. NASA, Aeronautics and Astronautics, 1971, p. 279.

Oct. 6 Radio astronomers obtain the first image of a distant galaxy from radio signals received by the Synthesis radio telescope near Westerbork, Netherlands. The image shows a whirlpool galaxy and publicity about it leads the U.S. Congress to approve construction of a large array of antennas in the southwestern United States. **New York Times**, Oct. 6, 1971, p. 43.

Oct. 7 U-2 reconnaissance aircraft survey and photograph the San Francisco Bay area as part of a U.S. Geological Survey project to gather continuous information as fast and as accurately as possible on urban growth patterns and development. The project has also covered the Phoenix-Tucson area in Arizona and the Baltimore-Washington, D.C., region. **New York Times**, Oct. 7, 1971, p. 35.

Oct. 6 Leatrice Pendray, the only woman among the founders of the American Interplanetary Society, later called the American Rocket Society and a predecessor of AIAA, dies in Princeton, New Jersey. She was the wife of another one of the founders, G. Edward Pendray. **New York Times**, Oct. 9, 1971, p. 30; Frank H. Winter, **Prelude to the Space Age — The Rocket Societies: 1924-1940**, pp. 73, 77-79.

Oct. 9 A two-stage, solid-propellant Rohini sounding rocket (RH-125) becomes the first rocket to be launched from India's new launching facility at Sriharikota Island near Madras. The rocket carries a 7-kilogram payload to 11 miles altitude. Previous flights of this model of the Rohini were made from the Thumba Equatorial Rocket Launch Station. **New York Times**, Oct. 9, 1971, p. 30.

Oct. 11 The Soviet Union's Salyut-1, the world's first crewed space laboratory, launched on April 19, reenters the atmosphere on command and disintegrates over the Pacific Ocean. **Baltimore Sun**, Oct. 16, 1971, p. A3; **Aviation Week**, Oct. 25, 1972, p. 14.

Oct. 13 The Soviet Union launches eight Cosmos lightweight satellites with a single Kosmos-3 booster from the Pletesk launch site that covers the Cosmos 444 to Cosmos 451 satellites. NASA, **Aeronautics and Astronautics, 1971**, pp.284-285.

Oct. 25 Mikhail K. Yangel, a Soviet scientist and rocket expert who served as the chief of the Soviet Union's space program from 1966 until his death, dies in Moscow. Born in Siberia as the son of a Ukrainian peasant and political prisoner, Yangel began his career as an aircraft designer and had been keenly interested in the possibilities of rocketry since the 1930s. He became the deputy chief designer under Sergei P. Korolev by the early 1950s and chief designer upon Korolev's death. NASA, **Aeronautics and Astronautics, 1971**, p. 297.

4 **Oct. 28** The United Kingdom launches its 66-kilogram Prospero (X-3) technology satellite from the Woomera Test Range in Australia on a Black Arrow booster, thus becoming the sixth nation to launch its own satellite with its own vehicle. The Prospero satellite carries experiments to test satellite technology and is the first and last U.K. satellite scheduled for launch on a U.K. booster. NASA, **Aeronautics and Astronautics, 1971**, p. 300.

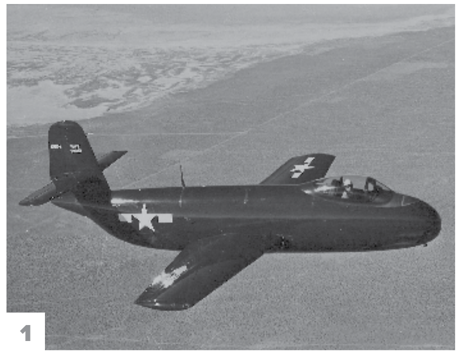
1996

5 **Oct. 10** NASA's Dryden Flight Research Center in California concludes its yearlong flight test program for the heavily modified General Dynamics F-16XL. Laminar flow "gloves" on the wings reduce drag and lower fuel consumption. NASA, **Astronautics and Aeronautics, 1996-2000**, p. 39.

Oct. 13 The Bombardier Global Express long-range corporate jet makes its first flight. The Global Express is built with a wide cabin cross section that can carry as many as 16 passengers comfortably. Two BMW Rolls-Royce BR710 turbofans give the aircraft a top speed of Mach .89 and a range of 12,000 kilometers. It can stay aloft for 14 hours. **Aviation Week**, Oct. 21, 1996, p. 17.

6 **Oct. 24** Aurora Flight Sciences' Theseus drone completes a series of tests at Edwards Air Force Base in California. The drone is designed to carry 300 kilograms of instruments to measure ozone depletion in the stratosphere and to validate satellite data for NASA's Mission to Planet Earth program for monitoring Earth's environment. The 43-meter span Theseus is powered by two Rotax 912 engines and can carry its payload up to 65,000 feet and remain aloft for 24 hours. **Aviation Week**, Nov. 4, 1996, pp. 29-30.

During October 1996 A new version of the Boeing 777 with a longer range is flown on its first flight from Boeing's facility at Everett, Washington. The 777-20ER has a range of up to 13,000 kilometers. **Aviation Week**, Nov. 11, 1996, p. 19.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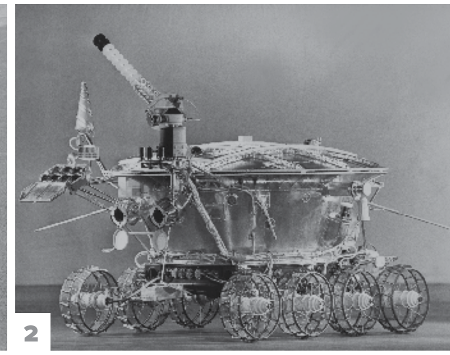
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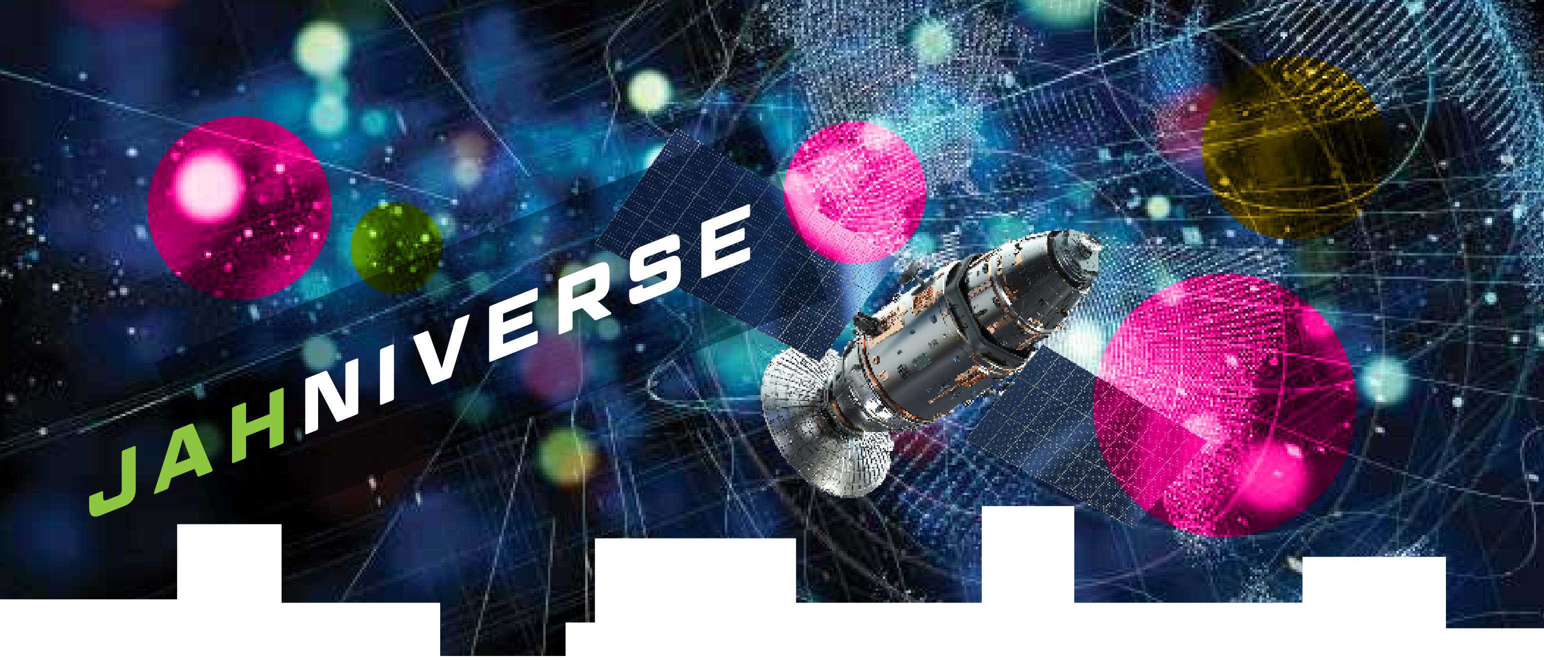

Why we welcome refugees

BY MORIBA JAH | moriba@utexas.edu

The world faces multiple crises, one of them being the fall of the government in Afghanistan and the exodus of hundreds of thousands of people seeking safety and refuge. Some pundits and observers in the United States will no doubt cast this mass exodus as a burden to Western nations, including ours, and at worst a national security threat. I know that not everyone's arms will be open here in America, but our government's history of welcoming refugees and immigrants, even in the face of discrimination and racism, is long and strong. We will come to see this tragic chapter in the history of Afghanistan as one that also freed thousands of Afghans to discover and pursue their aspirations. Some will pursue arts and literature or technical fields, including aerospace. Some will help defuse future global crises, whether those stem from climate change, terrorism or issues of war and peace among nations.

Why am I so confident about this small solace in the face of so much upheaval? Because of my own history as a child of immigrants to the United States. My story, and those of the arriving Afghans, can only be possible here. That is not to suggest that life will be easy or devoid of twists and turns for the refugees. It wasn't for me.

A girl immigrated to the United States from Haiti at 17 and met a man from Sierra Leone in San Francisco. I was a consequence of their meeting. Marriage ensued, and as with many marriages, theirs failed. I was just 2. Four years later, my mother and I relocated to Venezuela. As I grew, my relationship with my Venezuelan stepfather strained, and this led me to a military boarding school in Venezuela. I graduated at 17 and came back to the United States, feeling like an immigrant, although I was a citizen by birth.

I enlisted in the U.S. Air Force and found myself guarding intercontinental ballistic missiles at Malmstrom Air Force Base in Montana as a security policeman and defender. I would frequently notice dots of light moving steadily across the night sky. These were, of course, satellites and rocket bodies that humans had launched into Earth orbit. This memory came to my mind when I saw events unfolding in Afghanistan. What moments of inspiration like this might lie ahead for those lucky enough to find freedom here? Back at Malmstrom, I decided to leave the military to go to college so I could learn about space objects and the forces that motivated their celestial dance. My self-discipline gave me the confidence to take on the science of astrodynamics, but my Air Force commander did not want me to leave. When I declined to

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Moriba Jah is an astrodynamicist, space environmentalist and associate professor of aerospace engineering and engineering mechanics at the University of Texas at Austin. He holds the Mrs. Pearlie Dashiell Henderson Centennial Fellowship in Engineering and is an AIAA fellow. He also hosts the monthly webcast "Moriba's Vox Populi" on SpaceWatch.global.

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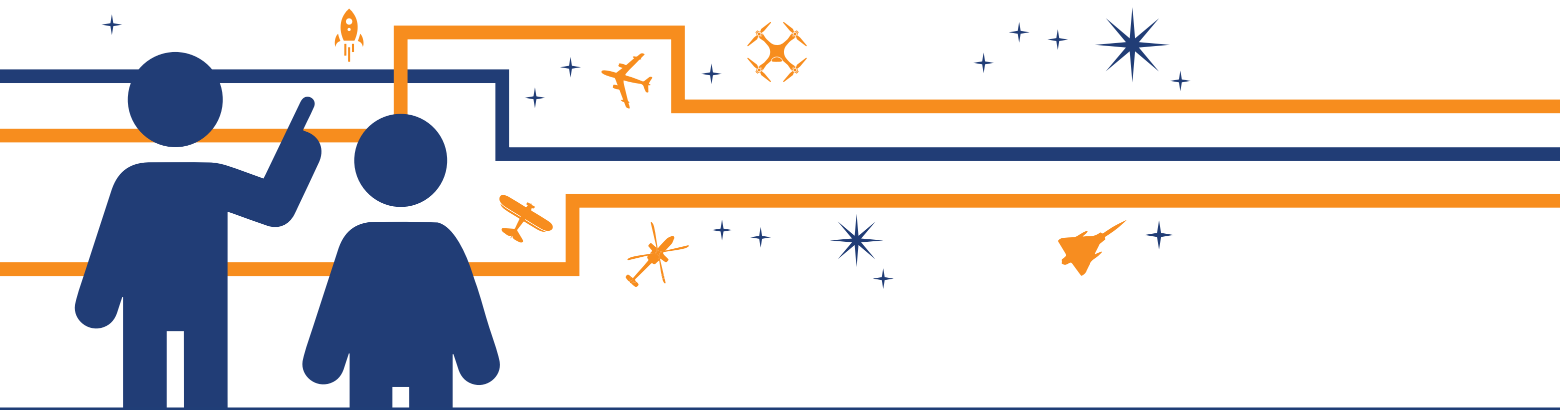

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