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AEROSPACE

★ ★ ★ AMERICA ★ ★ ★

TWO LAUNCHES TWO COMPANIES TWO BILLIONAIRES

New Glenn's partial success could give Blue Origin new momentum in its competition with SpaceX. Should gradatim ferociter get the credit? PAGE 22

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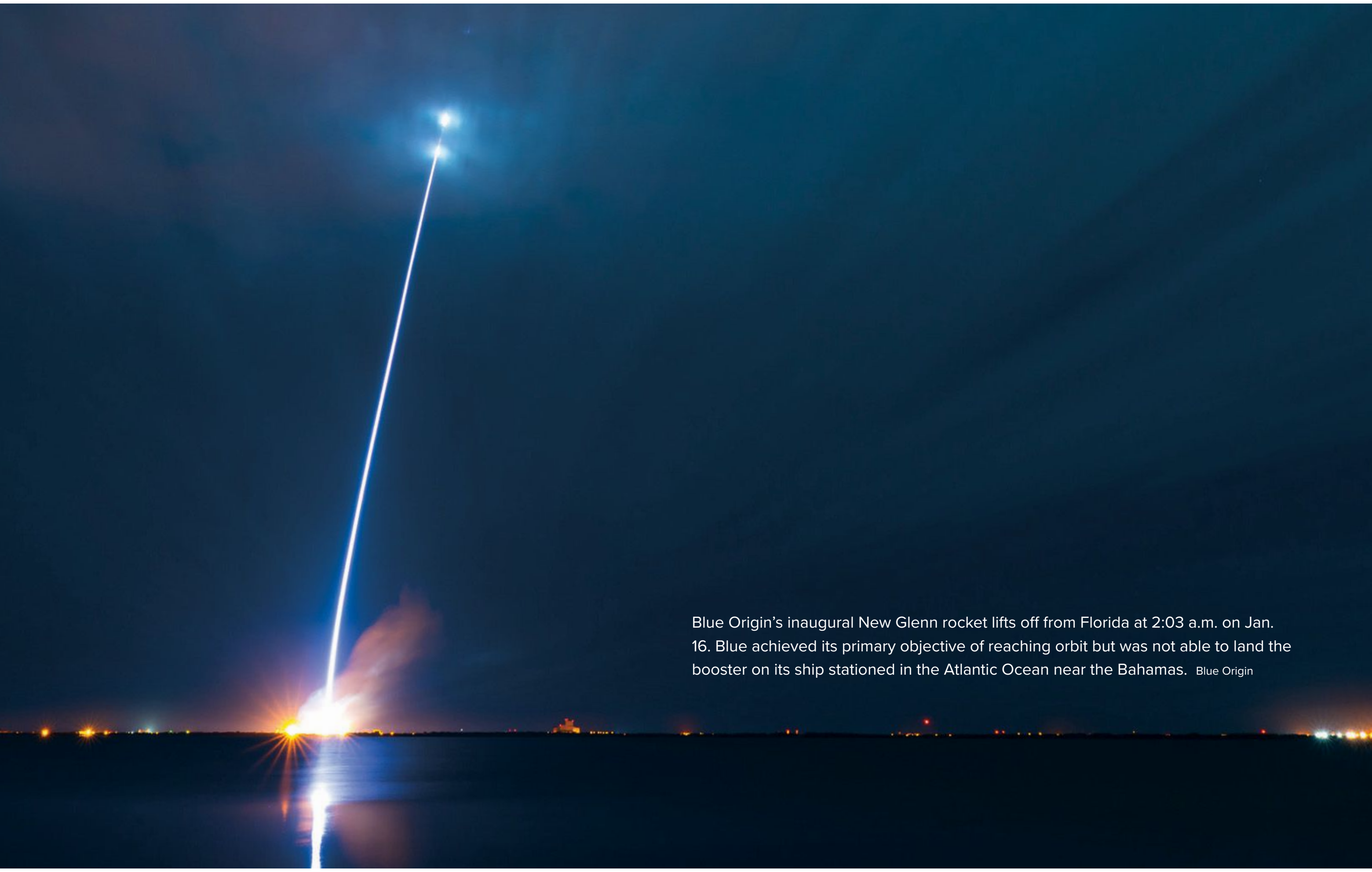
AIAA
SHAPING THE FUTURE OF AEROSPACE



Blue Origin's inaugural New Glenn rocket lifts off from Florida at 2:03 a.m. on Jan. 16. Blue achieved its primary objective of reaching orbit but was not able to land the booster on its ship stationed in the Atlantic Ocean near the Bahamas. Blue Origin

ON THE COVER: Starship-Super Heavy (left) and New Glenn on their launch pads in January. SpaceX/Blue Origin

AEROSPACE
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AIAA
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IN THIS ISSUE

Moriba Jah

Moriba is a space environmentalist, professor at the University of Texas at Austin and chief scientist at Privateer. He helped navigate spacecraft at NASA's Jet Propulsion Lab, researched space situational awareness at the U.S. Air Force Research Laboratory and is an AIAA fellow. PAGE 58

Jon Kelvey

Jon previously covered space for The Independent in the U.K. His work has appeared in Air and Space Smithsonian, Slate and The Washington Post. He is based in Maryland. PAGE 28

Paul Marks

Paul is a London journalist focused on technology, cybersecurity, aviation and spaceflight. A regular contributor to the BBC, New Scientist and The Economist, his current interests include electric aviation and innovation in new space. PAGE 16

Amanda Simpson

Amanda is a consultant, a former U.S. deputy assistant secretary of defense for operational energy, and a former head of research and technology at Airbus Americas, where she led sustainability efforts. An AIAA fellow, she's a licensed pilot and certified flight instructor. PAGE 56

DEPARTMENTS

Aerospace America presents readers with independently produced news and feature articles and a rich variety of opinions relevant to the future of aerospace. The views expressed in these pages are not necessarily those of our publisher, AIAA.

A Maxar satellite captured this short-wave infrared image of Altadana, California, on Jan. 8, a day after the fire started. The blaze was 95% contained as of Jan. 23, according to CalFire.

Maxar Technologies

Turning science into action against wildfires and climate change

We know we have many readers in the Los Angeles area, and our thoughts are with each of you. The following will not be much solace, but your pain has given us fresh determination to apply our reporting and writing skills to find and explore technologies and policy initiatives that could generate better results against wildfires. Some of those ideas, no doubt, will involve aerospace science and technology, and they will come from scientists, technologists, engineers and entrepreneurs in Southern California and elsewhere. If that's you, we would love to hear from you: editors@aerospaceamerica.org.

The losses in LA should, once and for all, inspire a national-scale effort by researchers and government policymakers here in the United States to take on the fire threat and, and more broadly, climate change and its consequences.

Scientists and forward-thinking policymakers have long warned us that our carbon footprint will likely drive unnatural changes to our planet. The fires painfully demonstrate that those changes are upon us.

We as a society need to do a better job of turning science into preparedness. A 2019 paper, "Observed Impacts of Anthropogenic Climate Change on Wildfire in California," now looks especially prescient. Writing in the journal Earth's Future, the authors warned of "increased atmospheric aridity caused by warming" and noted that "fuel drying is increasingly enhancing the potential for large fall wildfires." January is not the fall, but it's close enough. Many Californians in the years since have experienced exactly what the authors warned of.

What change did that paper and other warnings drive? Whatever was done was not enough. I scanned back over our coverage of aerospace-based wildfire technology. In fairness, American firefighting planes are no longer falling out of the skies, and a vibrant commercial industry of airborne services now exists. But wildfires still rule the night. Drones — the private ones — have been a collision menace in LA, not the help professionally operated ones could be at night and in the wind, when human pilots might not be able to go airborne due to unacceptable risks.

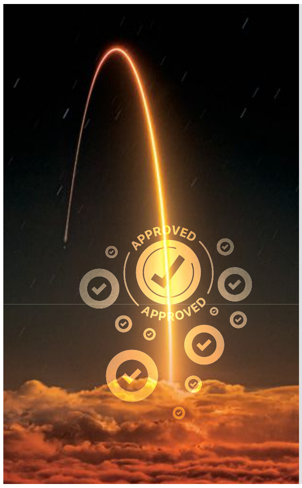
Overall, our current location on the climate change timeline reminds me of Winston Churchill's "Locust Years" of 1934 and 1935. He chose that phrase because time that could have been spent preparing defenses against Germany "was fruitlessly eaten up," according to America's National Churchill Museum.

It's time to accept that climate change is now a national-scale threat, not unlike terrorism, arms proliferation and nation-state aggression. The response to it should match.

Wildfires are one battle in this war. In the national security sphere, the Pentagon puts out a constant stream of requests for information to generate technology ideas, followed by requests for proposals to select and invest in the best of them. There does not appear to be a single entity coordinating and funding research and development across agencies and academia to meet the wildfire threat.

Perhaps that is a place to start. ★

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



CORRECTION:
The January feature, "Permission to launch," provided an out-of-date affiliation for Brian Weeden. He is a systems director in the Aerospace Corp.'s Center for Space Policy and Strategy. The online version has been updated.

CLARIFICATION:
The January Q&A, "Chaos tamer" has been updated online to clarify the number of employees that FAA's Tim Arel oversees. As head of the Air Traffic Organization, he manges two-thirds of FAA's workforce.

LET US HEAR FROM YOU

Send letters of no more than 250 words to letters@aerospaceamerica.org. Your letter must refer to a specific article and include your name, address and phone number. (Your address and phone number won't be published.)

FLIGHT PATH

A Transformative Year in Aerospace – Top Trends From 2025 AIAA SciTech Forum

I could not imagine a more exciting way to kick off the new year than attending my first AIAA SciTech Forum, and to do so as the CEO of the Institute.

As our industry's premier aerospace R&D event, the forum brought together over 6,000 of the best engineering minds from industry, academia, and government to "Energize the Future." With a focus on science and technology breakthroughs, as well as collaboration across our community, the forum explored how we are enabling new means of transportation and exploration that will revolutionize society and improve efficiency to help achieve our sustainability goals.

The quality of the conversations on the main stage – from Mars rovers to supercomputing to artificial intelligence – remain with me. We delved into the most important advances coming from our community to inform my top trends that will affect aerospace in 2025.

There was so much more that we discussed surrounding these trends during the forum. You can view the forum proceedings in our impressive Aerospace Research Center (**arc.aiaa.org**) to gain the insights you need for your pursuits this year. I look forward to building on the ideas and energy from this year's forum to engage with our entire community as we look to make an indelible impact this year.

2025 AIAA SciTech Forum by the Numbers

Nearly 6,200 Attendees	2,000+ University Students	Nearly 2,900 Technical Papers	127 AIAA Associate Fellows Inducted	104 Exhibitors

Top Trends From 2025 AIAA SciTech Forum Transforming Aerospace This Year

#1. The Power of AI / Gen AI

Artificial intelligence (AI) and its generative cousin dominated forum conversations. We heard that 90% of the world's data was created in the last three years, with 94% of it unstructured. GenAI systems leverage vast datasets to autonomously generate novel solutions and designs, enhancing innovation and applications, allowing you to optimize materials, scale production, validate and qualify solutions, and speed decision making.

Alexis Bonnell, chief information officer and director of Digital Capabilities Directorate for the Air Force Research Lab (AFRL), otherwise known as AFRL's AI evangelist, told us, "Technology fails when it fails to serve people." Bonnell made a powerful case for changing the narrative on AI to make it more accessible while urging CIOs to lead differently.

#2. Advanced Air Mobility Kicks into Another Gear

Aviation's focus on electrified aircraft and advanced air mobility (AAM) was explored in depth. Hybrid and electric take-off and landing (eVTOL) aircraft builders showcased their firms' capabilities, while the U.S. AAM Interagency Working Group convened to discuss R&D policy and the current state of infrastructure, investment, and public acceptance required to keep AAM momentum going.

AAM proponents face notable hurdles on their path to creating a robust and healthy ecosystem. Some of the larger issues include the need for a national electric grid connected to regional ones that enable multi-modal transportation options as well as localized weather infrastructure that can measure and forecast low-altitude weather so traffic controllers can safely do route planning for air vehicles. In its just released report (**aiaa.org/domains/aeronautics/certification**), the AIAA Certification Task Force proposes solutions to many of these challenges.

The ultimate sign that all-electric aircraft are safe and trustworthy is when aircraft founders get into the cockpit. Read more on these flights from *Aerospace America* (**aerospaceamerica.aiaa.org/advanced-air-mobility-founders-show-trust-in-their-technology**).

#3. Green Propulsion as the Way Forward

Aviation OEMs and spacecraft builders are all embracing green propulsion and with good reason: It offers a high-performance, high-efficiency alternative to conventional chemical propellants. It's also key to achieving carbon net-zero in aviation by 2050. That's important given that the transportation sector leads emissions over power generation, according to the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E).

"Aerospace is one of the hardest sectors to decarbonize," admitted Peter de Bock, program director for ARPA-E, during a panel on sustainability.

In 2025, we expect widespread adoption of electric propulsion systems for both aircraft and spacecraft, significantly reducing emissions and paving the way for more environmentally friendly air travel.

"We see huge opportunities in hydrogen," said Michael Winter, chief science officer at RTX. Winter noted a new hydrogen steam-based turbine engine concept has been shown to be 35% more efficient while reducing oxides of nitrogen by 99.3%.

The forum also covered space-based propulsion and the potential of using nuclear power in the atmosphere for atmospheric propulsion, which *Aviation Week and Space Technology* magazine editors highlighted on their post-event podcast (**aviationweek.com/podcasts**).

#4. Hypersonics Pushing Ahead

We heard about advances in hypersonics through the numerous sessions of the 26th AIAA International Space Planes and Hypersonic Systems and Technologies Conference held alongside the forum, especially in the eight country reports.

In addition, this year's presenter of the Durand Lecture for Public Service, Kevin Bowcutt, principal senior technical fellow and chief scientist of Hypersonics at The Boeing Company, shared his overview of the history and prospects of supersonic systems. He noted that the emergence of multidisciplinary design optimization developed over the last 25 to 30 years, is a positive step helping hypersonic system designers optimize their designs through modeling tools to help solve integration challenges faster.

FORUM NEWS

WATCH SESSIONS

#5. Prioritizing Software & Digital Transformation

Software remains vital to our nation's global competitiveness, innovation, and national security. Under the leadership of Carnegie Mellon University's Software Engineering Institute (SEI), the United States is creating a multiyear R&D vision and roadmap for engineering next-generation software-reliant systems. "Software engineering is … not only a national but a global priority," said Ipek Ozkaya, director of Engineering Intelligent Software Systems at Carnegie Mellon's SEI.

The agenda goes hand in hand with aerospace's focus on digital transformation, which extends beyond commercial companies to include the U.S. Air Force and Space Force. The forces are prioritizing digital engineering across their science and technology portfolio, as we heard from Kristen Baldwin, deputy assistant secretary of the Air Force for Science, Technology, and Engineering, in her plenary remarks.

#6. Embracing Robotics and Autonomy

Autonomous systems are making their mark across the aerospace landscape, from the rise in advanced air mobility to the growing commercial presence in space, and rapid developments in defense systems.

During a plenary, Marco Pavone, lead autonomous vehicle researcher at Nvidia and an associate professor at Stanford University, said, "This is a golden age for robotics and autonomy," and he isn't alone in that sentiment.

"I foresee the first habitable, critical infrastructure on the surface of Mars being constructed by a team of robots," added Eric Smith, senior principal, Remote Sensing and Data Analytics at Lockheed Martin Space.

Smith also contends that autonomous systems will one day transform the speed and effectiveness of first responders, including how firefighters predict, detect, and fight wildfires.

#7. Combating the Climate Crisis from Space

NASA and commercial partners are making headway with space-enabled Earth observation advances that can detect greenhouse gases from space, track fires, and help predict natural disasters. JPL is working to identify super emitters like methane, an odorless gas invisible to the naked eye that is responsible for 30–40% of global warming. Runaway methane leaks in pipelines cost oil and gas companies $1 billion a year, noted JPL Director Laurie Leshin. Methane is visible now from orbit thanks to the Earth Surface Mineral Dust Source Investigation (EMIT) mission attached to the International Space Station (ISS).

Insights from JPL's Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station, or ECOSTRESS mission, are helping cities find hot spots. This allows Los Angeles to alleviate the heat issue by testing a reflective coating on streets that provides a noticeably cooler environment.

Lockheed Martin also is exploring advanced technologies to help firefighters better predict, detect, and fight wildfires. Using the power of AI, their technology could analyze fire behavior in near real-time to enable fire growth predictions and to deliver persistent communications across multiagency air and land suppression units, so they might respond quicker to a large complex fire.

#8. Sustained Human Presence – In LEO, on the Moon, and on to Mars

A major highlight was NASA's unveiling of its Low Earth Orbit Microgravity Strategy, which calls for a continuous heartbeat in orbit. That's what we've enjoyed for the last 24 years thanks to the ISS – "a true, unbroken, continuous presence, where there's always a person living and working in space," said Jim Free, NASA associate administrator, noting that if the United States doesn't maintain a continuous heartbeat, it risks ceding low Earth orbit to others.

Our quest to return humans to the lunar surface in preparation for landing on Mars will see major momentum. Two private moon landers already launched this year: Texas-based Firefly Aerospace's Blue Ghost lunar lander and iSpace of Japan shared a ride on the same SpaceX Falcon 9 rocket. We're anticipating Blue Origin's MK1 Lunar Lander pathfinder launch and the European Space Agency's first orbital test flight of Space Rider, its uncrewed spaceplane, as well as ongoing preparations for the Artemis program.

To ensure we are ready, NASA is funding next-generation spacesuit designs using virtual digital twins. The space agency is now accelerating plans to safely bring back Mars samples that could prove the existence of life there, reported JPL's Leshin. NASA also is studying turbulence while flying and landing on Mars by tapping into Frontier, the world's first exascale supercomputer, housed at Oak Ridge National Laboratory. Read more from the plenary featuring Frontier (**aiaa.org/SciTech/program/news-about-aiaa-scitech-forum**).

A bonus trend is the acceleration of reusable launch systems, especially heavy-lift vehicles. In the week immediately following the forum, Blue Origin debuted its heavy-lift vehicle, New Glenn, and SpaceX tested its Starship for the seventh time. The companies gained valuable engineering data from their tests, seeing both success and tough learnings. Reusability is the future of launch, which will accelerate the growing space economy by reducing costs, expanding access to space, and helping return us to the moon and on to Mars. ★

Clay Mowry, AIAA CEO

Why hybrids have the U.S. military's eye

BY PAUL BRINKMANN | paulb@aiaa.org

▲ Electra in Virginia unveiled the design of its planned production aircraft, the EL9 Ultra Short. Electra

The director of the U.S. Air Force division that researches emerging electric aircraft is eager to see one or more of those designs transitioned into active military service.

The first to be transitioned will almost certainly be a hybrid-electric aircraft rather than battery-only, due to the need for range of over 240 kilometers and for payload capacity of over 90 kilograms, said Lt. Col. Jonathan "Spades" Gilbert, who runs the Prime Division of AFWERX, the innovation arm of the Air Force. I interviewed him in front of an audience in the exposition hall at AIAA's SciTech Forum.

"We are focused on how we transition and who we are transitioning to," Gilbert said. "That's a major challenge at times in the vast [Department of Defense] bureaucracy of program offices and requirements. We're focused on meeting the current needs of the program offices out there."

Agility Prime is one of two programs under the Prime Division, the other being Autonomy Prime. The programs aim to "prime" commercial markets to produce technology that benefits the armed forces.

Gilbert is looking for further guidance from the Office of the Under Secretary of Defense for Research and Engineering, which has been tasked by Congress with setting up a working group to identify programs of the armed forces that could benefit from electric or hybrid-electric aircraft. That directive is in the National Defense Authorization Act for Fiscal Year 2025, passed by Congress and signed by former President Joe Biden in December.

Agility Prime's flights of battery-only electric aircraft capable of vertical takeoff and landing were informative. Those included an ALIA aircraft from BETA Technologies of Vermont, an S4 from Joby Aviation of California and a Midnight aircraft from Archer Aviation, also of California. The benefits of any electrified aircraft include lower fuel requirements, quieter flight and the ability to instantly spin up electric engines for quick takeoff, Gilbert said. However, "we are starting to see the limitations of all-electric," which are "namely range and payload."

"So that's where the hybrid-electric comes in, because I can get a lot of the benefits of the electric system, but now I can increase range and payload. It's a win-win for everything."

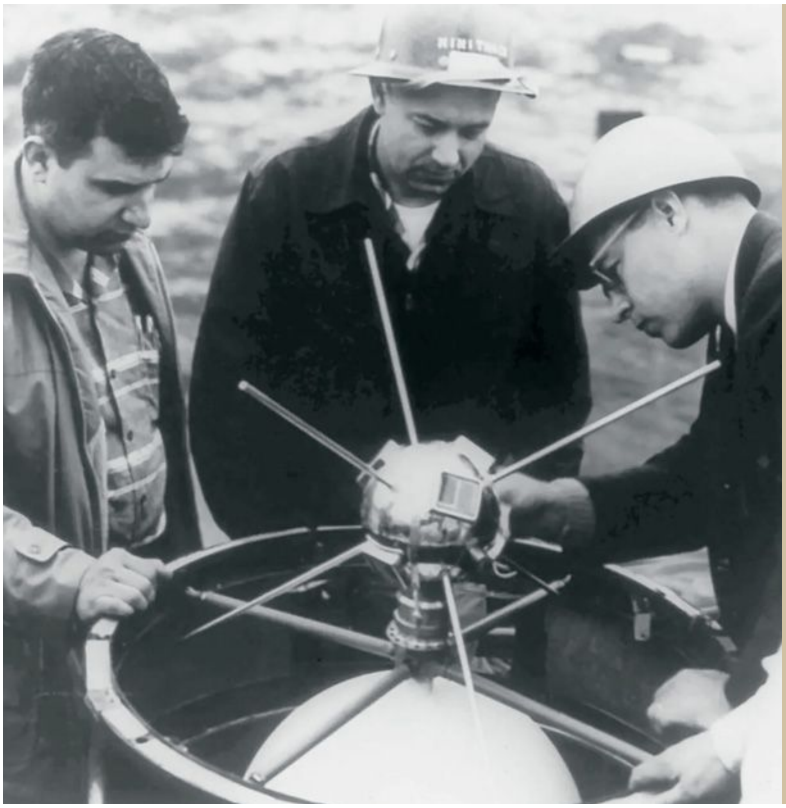
Such capabilities will "shape a lot of future efforts in advanced logistics, particularly in the Pacific Theater," Gilbert said. "Instead of having large bases in a couple locations, I may have tens or hundreds of bases that I have to resupply with shorter legs but up to 1,000 miles [1,600 km]. For that, I'm going to need something more capable than what we are currently seeing out of the electric-only."

While the range of battery-electric aircraft varies and is increasing, current models have a maximum range of about 450 km, while at least one hybrid-electric aircraft evaluated by Agility Prime has a range of 2,000 km.

Despite the advantages of hybrid, Gilbert said Agility Prime is not done evaluating all-electric designs. He said the Army in particular has an interest.

And regardless of whether an all-electric aircraft is transitioned to military service, Gilbert said developers of such aircraft have advanced the capability to rapidly manufacture emerging novel aircraft designs.

"Some of these all-electric aircraft companies have made incredible leaps in manufacturing technology. I think that's an area where industry is far outpacing the current [U.S. Air Force] sustainment centers in aircraft manufacturing," he said. ★



Bringing home a piece of space history

BY CAT HOFACKER
catherineh@aiaa.org

◀ U.S. Naval Research Laboratory employees prepare the Vanguard 1 satellite for launch.

Naval Research Lab

The Vanguard 1 spacecraft narrowly missed out on the distinction of being the first U.S. satellite, an honor that of course goes to Explorer 1. It is, however, the first satellite to convert sunlight to electricity.

Now, the grapefruit-sized aluminum sphere with spike-like antennas could gain another distinction. Engineers and a research analyst from Virginia-based consulting firm Booz Allen Hamilton have suggested that Vanguard 1's owners could capture it in orbit and return it to Earth. They outlined how this might be done in the paper, "Retrieving History: Options for Returning Vanguard 1 to Earth," presented at AIAA's SciTech Forum in January.

Recovering satellites isn't a new concept. NASA demonstrated one technique in 1984, when spacewalking shuttle astronauts snared two malfunctioning communications satellites and reeled them into the Discovery orbiter's cargo bay. Despite that success, satellite retrieval never took off. Now, however, interest is on the rise, given the orbital debris problem and the desire to extend the lives of satellites by repairing or refueling them in orbit.

Vanguard 1 is the perfect combination of "enormous historical value" and technical challenge for demonstrating techniques needed in the growing servicing field, says Matt Bille, a Booz research analyst and lead author of the paper.

Bille and his co-authors emphasize that this isn't a formal business proposal or an official Booz project. Bille shared the paper with the Naval Research Laboratory, which built and owns the satellite, and with NASA, which took over responsibility for Vanguard 1 in the late 1950s. So far, he says, there have been no additional discussions, but he learned that both organizations are separately looking into the possibility of a recovery mission.

The authors believe the best option would be a two-part mission: First, assess Vanguard's condition, likely with a spacecraft equipped with cameras to take images and other measurements at a close range. The paper mentions a handful of existing spacecraft that have demonstrated this observing technique, including Astroscale Japan's ADRAS-J. That spacecraft spent much of last year approaching and inspecting a dead rocket upper stage in preparation for a planned deorbiting later this decade.

A big question is whether capturing Vanguard is even feasible, given that its multiple antennas "are now presumed to be too fragile to use as grab or attachment points," the paper reads.

If the assessment shows that retrieval is possible, the next decision would be whether to send a semi-autonomous craft or a human crew.

For the robotic option, an upcoming DARPA-funded demonstration might illustrate one technique: NRL is attaching a set of robotic arms, plus accompanying cameras and software, to a spacecraft frame built by SpaceLogistics, a Northrop Grumman subsidiary. That craft is to be launched to geosynchronous orbit later this year, where it will approach a handful of defunct communications satellites and, with its robotic arms, attach fuel jet packs to them. Perhaps a similar bus could grasp Vanguard.

For the crewed scenario, one possibility would be sending a modified SpaceX Crew Dragon capsule, similar to the one in which billionaire Jared Isaacman and three other passengers rode in September. Given that Dragon's nose opening was large enough for Isaacman and SpaceX engineer Sarah Gillis to squeeze through for their "stand-up EVA," the authors suspect the crew could bring Vanguard 1 into a Dragon that way and robotically package it in a container for the return trip.

"There's a lot of options to be studied here in more depth than we were able to do in just the paper. But the point is, it's a plausible mission," Bille says. ★

Autonomy realist

Ella Atkins has been researching and publishing papers about autonomy in aerospace for decades, but her work is now in higher demand as innovators in the developing electric air taxi industry contemplate increasingly automated flight — perhaps even without pilots on board. I met with Atkins in January at AIAA's SciTech Forum in Orlando, Florida, to discuss the history of automation in transportation, the technical challenges behind self-driving cars versus automated aircraft, and the challenge regulators face in certifying aircraft software that must continue to learn with each flight. — *Paul Brinkmann*

ELLA ATKINS

Positions: Since 2022, professor and head of Virginia Tech's Kevin T. Crofton Department of Aerospace and Ocean Engineering • Since 2018, editor of AIAA's Journal of Aerospace Information Systems • 2016-2022, aerospace engineering professor at the University of Michigan • 2020-2022, technical fellow in mission systems at Collins Aerospace/Raytheon Mission Systems • 2016-2020, associate director of the University of Michigan's Robotics Institute • 2006-2016, aerospace engineering associate professor at the University of Michigan • 1999-2006, aerospace engineering assistant professor at University of Maryland • 1993-1999, graduate student fellow and research assistant at University of Michigan • 1990-1993, project engineer at Structural Dynamics Research Corp. • 1988-1990, graduate student research assistant at MIT.

Notable: Private pilot • Author of some 250 journal and conference papers on AI-enabled autonomy • Part of a team that, with NASA researchers, developed an assured contingency landing management architecture and flight planner that develops contingency landing plans to minimize in-flight response time • Researched self-driving car crashes based on YouTube dashcam clips to supplement published datasets, resulting in co-authorship of the paper, "Unsupervised Traffic Accident Detection in First-Person Videos." • Co-founded the robotics program and institute at the University of Michigan.

Age: 58

Residence: Blacksburg, Virginia

Education: Ph.D. (1999) and Master of Science (1995) in computer science and engineering from the University of Michigan; Master of Science (1990) and Bachelor of Science (1988) in aeronautics and astronautics from MIT.

Q: How did automated transportation begin?

A: When you fly through Atlanta, you take a train between terminals. There's no person in that train driving it. Instead, there are pre-recorded messages; there are sensors that tell the train where it is; sensors on the doors that open and shut them and detect people. Sometimes the trains go down when they're fixing things, but they're pretty reliable. I didn't even notice in Orlando [International Airport] whether there was a train driver or not, because I felt very comfortable. And if you look at why a train in, say, an airport like Orlando or Atlanta was first to be automated, it's because of the controlled environment. The train is on a track of some sort, and you don't have to steer it. You just have to go slow enough that it's not going to derail, and the tunnels are controlled, so you don't expect to need to detect people who might get in front of the train.

Q: In aviation, autopilot has been evolving and getting more sophisticated over the years, right?

A: The first autopilots just maintained altitude and heading, and the instruments for that were fairly straightforward. The altitude was pressure based, and the heading was compass based, and you did not need sophisticated computers or software to dial in on a heading or follow the pressure sensor to a particular altitude. You might be off by a little bit, but if you're flying at several thousand feet, the amount that you would be off would be within margins for being safe. And back then, there were not so many airplanes. Then, more instruments were created because pilots were getting lost. We had some avionics-based autopilots that basically would just maintain altitude and heading. And then once computers got to the point where they were small, lightweight, low-power systems that could fit in an aircraft, that's when we transitioned to what we know as the flight management system.

And then we got all of these options with a small computer screen that the pilot could enter data on, and that was more sophisticated than just an altitude and a heading. And then we got GPS, and things kind of snowballed from there. Suddenly, with all of the sensors that we traditionally have had on board to measure inertial conditions and air speed and side slip and angle of attack, we're able to now have a really reliable estimate of state for the aircraft. Along with emerging feedback controllers that were quite good, and guidance algorithms, we ended up with true autopilot, as long as the data is available.

Probably the biggest advance was in fuel management. The cockpit crew in modern aircraft went down in the 1980s from three to two people when the flight engineer was not needed anymore.

Q: They had an extra person on board, an engineer, just to monitor fuel management?

A: Yes, the flight engineer looked at engine temperatures and condition and projected forward whether there was enough fuel to land. In the 747, there were two people facing forward, and then there was one person facing sideways, because that flight engineer did not need to look out the windshield; they were looking at a panel of instruments and had a series of knobs that they turned. So they would be responsible for switching between fuel tanks, monitoring everything with the engine, pressures, temperatures, everything that allows them to determine if they thought an engine was going to have a problem.

This was a set of functions that software excels at, because it's all math. That's all monitored by software now. Every engine has a FADEC, a full authority digital engine controller. All of the work the flight engineer used to do is now done by this computer inside the engine. And that is a big step forward for jet engines, because the FADEC can now monitor hundreds, if not thousands, of sensor measurements. There are measurements of vibration, because an early indication that your jet engine might be having problems is if you have vibration. If you have some kind of vibration happening, it will actually adjust the parameters of fuel flow and

> "A reason that pilots have to take over often is that we have made the choice to have a continuation of voice-based communication that does not go through the computers."

"You just can't freeze systems that have been optimized around using AI or machine learning. You have to let them learn, just like a person has to be able to learn on the job."

turbine speeds to try to manage it without shutting the engine down.

This is important, because that is the last time we actually took a person out of the airplane and replaced that person with software. The computer was doing what it does better than people, and nobody questions that. It's almost unheard of now that a modern jet aircraft has run out of fuel. Even so, airlines are in no hurry to downsize the crew any further.

Q: I'm often hearing the term "operator" today instead of "pilot" in some situations. What do you make of this shift in how we describe the person controlling an aircraft?

A: I'm wondering if this change from "pilot" to "operator" actually has any substance, or whether it's actually something that allows those who feel they are real pilots to ridicule those who are operators. I do know that a pilot of a commercial aircraft often does the same thing that an uncrewed aerial system operator on the ground does. They monitor screens and software, and they push buttons and turn sticks that go through the computer fly-by-wire. The only difference is that the person on the ground doesn't have a shared fate.

Even with high levels of automation, pilots would tell you it's the most dangerous and high-workload time that the most critical decisions are made, and they need all of their understanding as both a pilot and somebody who's paid attention to the control software. Pilots actually need to understand what's going on in the software well enough to determine whether it's working. If they don't, we call that mode confusion. The reason mode confusion happens in many cases is not that the pilot is a loser but that they didn't actually have an understanding of the different logic functions that were going on in the aircraft.

A reason that pilots have to take over often is that we have made the choice to have a continuation of voice-based communication that does not go through the computers. The flight management system was never designed to push all of the buttons that needed to be pushed.

Q: Then we have the concept of autopilot, or self-driving cars. How did that evolve and when?

A: Car companies became aware that having some

automation was helpful as far back as the 1970s. For example, airbags automatically deploy, and antilock brakes automatically stop you when you begin to slide. Even antilock brakes were considered controversial in the 1980s.

Other examples of automation being introduced were traction control, cruise control and lane steering, where there were systems that would detect where the lines were, where the edge of the road was, and alert you. So, you don't wake up one morning and have self-driving cars; you build it from the ground up. All of these things happened in the traditional auto world before automobile autopilot existed. They're all building blocks. So, there's no secret sauce about self-driving cars. What was new was integrating them all together with a computer that called itself an autopilot.

In cars, we have levels of autonomy. Level 0 is the driver doing everything. Level 5 is where you don't need lane markers or other signage that a car camera can easily reference; the car will drive itself with no intervention. The first autopilot in cars offered commercially was sold as Level 2, which means that it can hold itself on the road and maintain speed, but the driver always needs to be vigilant to take over.

The problem is the public doesn't really know the different levels of autonomy. So even though they said this is a Level 2 product, the customer said, "The autopilot can drive my car, and all I have to do is hold my left hand on the steering wheel." And then there were people that did things like hanging a weight from the steering wheel and getting in the back seat to play games or take a nap. So the customers did not use it appropriately.

Q.: Moving on, everything that's been learned so far is now being contemplated for more fully autonomous aircraft, correct?

A: Yes. Flying an airplane, although it's scarier and three dimensional, is actually easier than driving a

▲ The self-driving car company Waymo, owned by Google's parent company Alphabet, operates autonomous taxis on city streets in Los Angeles, San Francisco and Phoenix.

Waymo

car for several reasons. One is there's no pedestrians, bicycles, animals and so forth.

We know where the planes are now, very accurately. That means that the problem of each airplane knowing where the others are has been solved. That is a huge deal that has not yet happened for cars; the automation problem for aircraft is actually easier. The thing that is more complicated, in a nutshell, is contingency management, which is where I've focused most of my career. And the reason that's harder is that with a car, your goal is to stop and pull off to the side of the road. If you can't make it to the side of the road or to an exit ramp, you stop in the road. However, if you're up in the air, maybe at several thousand feet, there's an entire sequence of things that you have to do to be safe. If you just stop, you fall out of the air. You have to figure out how to get down on the ground safely, and that really is tricky.

Once you get into low-altitude environments, the problem changes from clear airspace to "I need to actually avoid stuff." And whether it's mountains or power lines or cell towers or buildings, maps today are not perfect, and we actually need to pay attention. We have a very rigorous process for deciding whether houses and towers and so forth can be built adjacent to major airports, so you don't have an unknown cell tower that pops up right before you're going to land right at Orlando. But if you're going to land at a random vertiport in an urban area, it's possible that something could have popped up, and it's not on the map. For example, construction cranes are not really ever mapped on aviation charts, and they're pretty tall. So, you actually have to be able to detect things like that. The path forward — which I think NASA is interested in, and I know that I'm interested in — is how to mine other data types. For example, construction permits in cities, which could tell you there might be a construction crane right over there.

Q: Currently, FAA hasn't embraced the use of artificial intelligence in flight, but is that coming soon, and when do you think AI might be more widely embraced in aviation?

A: When it comes to FAA, they've made a distinction as to whether artificial intelligence or machine learning is used strictly before certification or whether it's also allowed to continue learning and evolving after certification. Right now, there are a couple of systems for collision avoidance, for example, that were based on something called the Markov decision process, which uses something called reinforcement learning, a machine learning technique. That particular collision avoidance system, because it was developed by machine learning and AI, FAA regulators decided that they would certify a frozen version of it. Frozen means that it's finished learning.

▲ One of EHang's EH216-S approaches downtown Shanghai in a January demonstration flight. The Chinese electric aircraft developer has been flying its pilotless two-seat aircraft in cities across China to demonstrate safe operations and "realize the urban air mobility in mega central cities," EHang said in a press release.

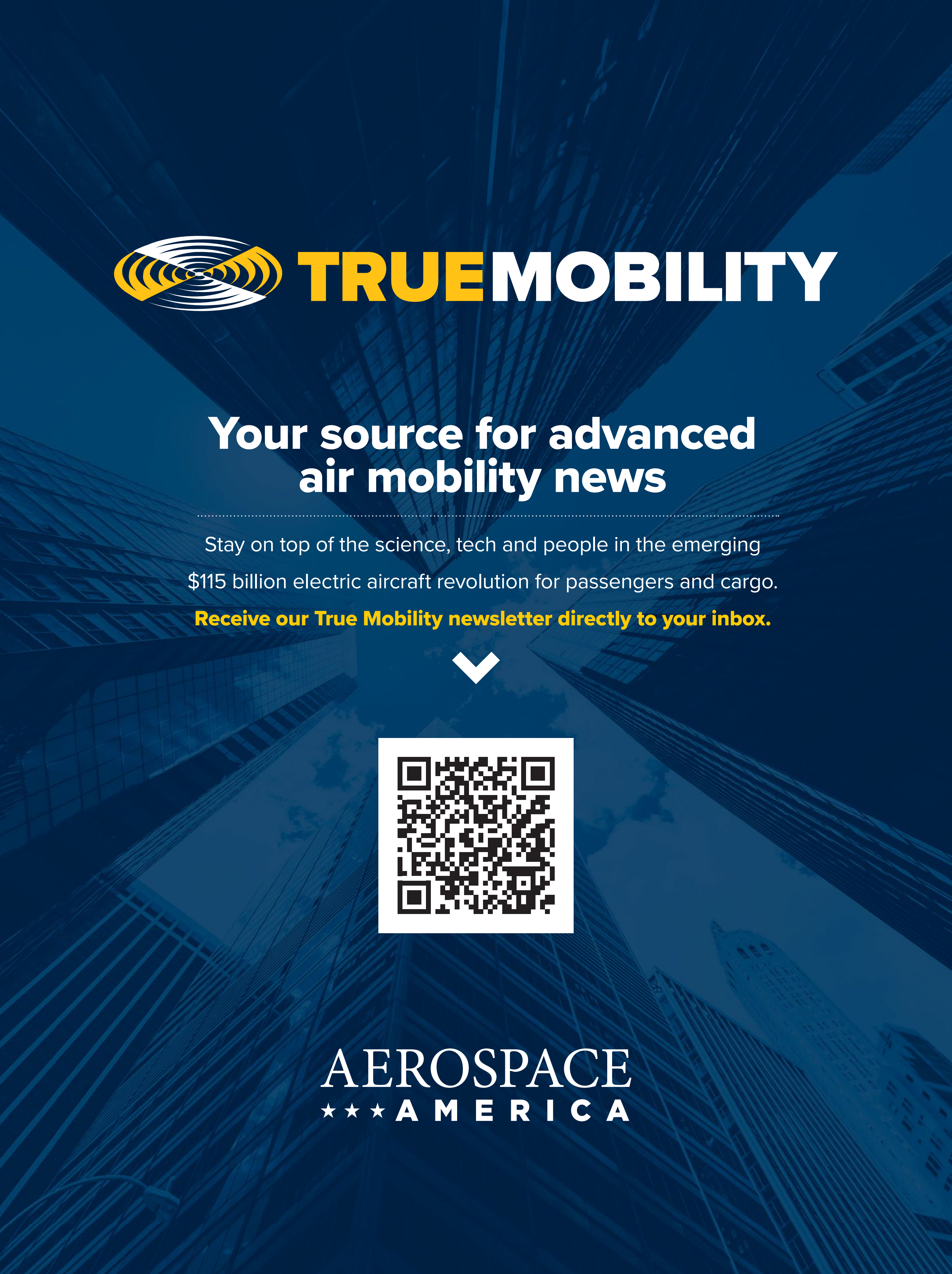
EHang

Can you imagine if we froze the human brain and said, "You're finished learning"? You just can't freeze systems that have been optimized around using AI or machine learning. You have to let them learn, just like a person has to be able to learn on the job. It's not AI or machine learning if you froze it; it's just a bunch of if-then statements with some math. Anything you freeze like that is no longer AI.

Q: In China, EHang is already selling electric vertical takeoff and landing aircraft that have no pilot on board, so they are totally automated. What do you make of that?

A: In China, it's a different environment ever since the commercial drone companies emerged and DJI captured a lion's share of global markets. They were like, "Hey, there's a business opportunity here." The public and the government have been aligned to see how far they can take this. But here, the public and the government have tried to stop it because there's fear.

China is doing the same things that we know how to do. They just don't have the same constraints on releasing them into a product. There's no reason to believe that they have a secret sauce that goes beyond what we know how to do. We just don't have approval to do it, and our companies are skittish, and our passengers are afraid. ★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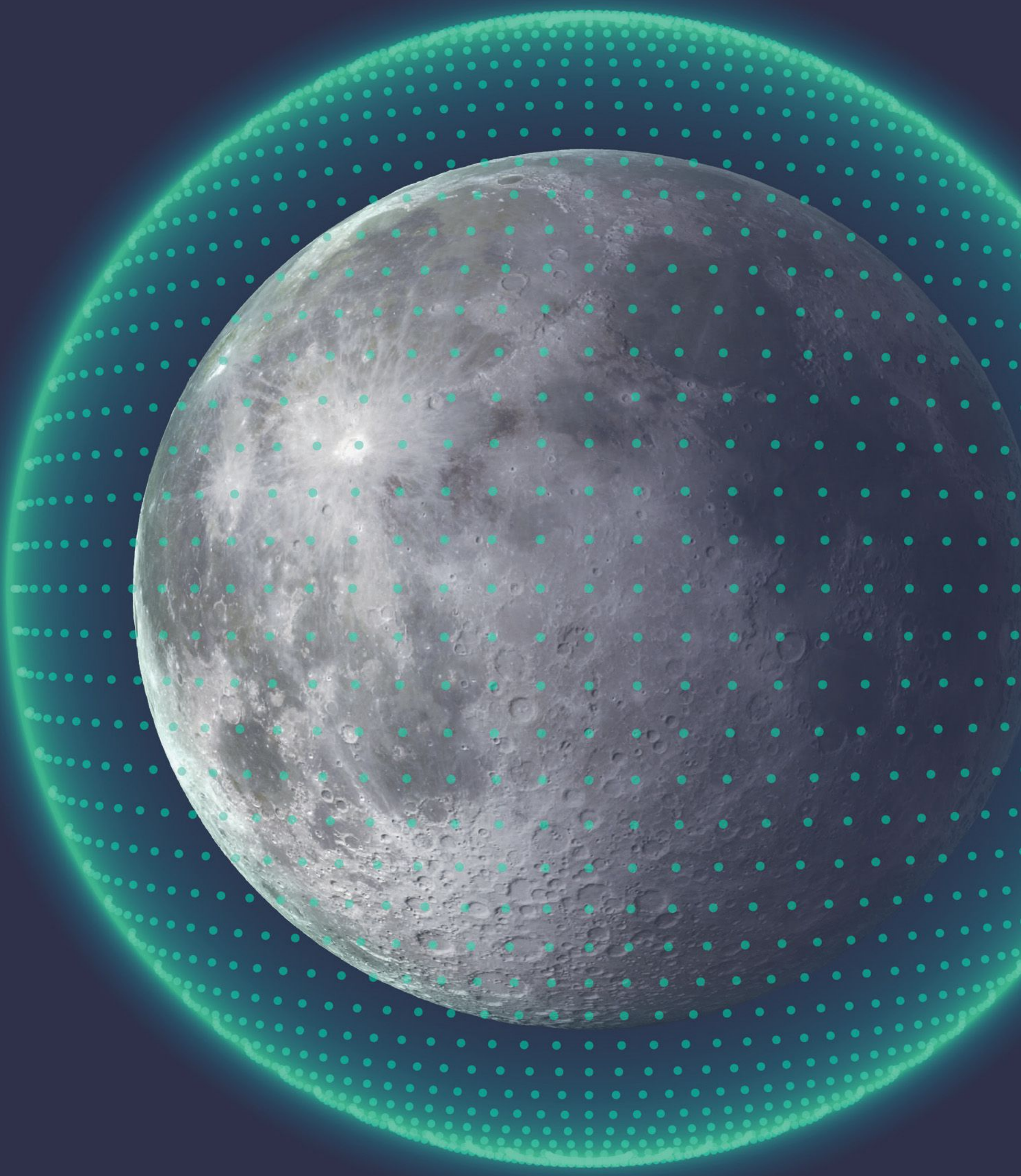


Beating the fear of darkness

A constellation of space-based solar power satellites in lunar orbit could, as soon as 2028, be ready to wirelessly power lunar landers and rovers through the grueling cold of the long lunar night. Paul Marks tells us about the progress to date.

BY PAUL MARKS | paul.marks@gmail.com

In Isaac Asimov's 1941 short story "Reason," the narrative unfolds on a sprawling, kilometers-long spacecraft stationed near the sun, its role being to convert solar energy into a power beam that it transmits to Earth. In other words, it was Asimov who first conceptualized space-based solar power stations, a technology that China, Iceland, Japan and the United Kingdom are considering fielding in the next decade. These stations would harvest solar power on kilometer-scale arrays, convert it to microwaves and beam gigawatts of it to grid-connected antennas on Earth, from geostationary orbit.

But here's the thing: Earth might not be the first recipient of power from a working space-based solar power system. Spacecraft on the surface of the moon could be first to benefit, and potentially as soon as 2028.

That's the aim of the Canadian startup Volta Space Technologies. This small company in Montreal plans to fly a constellation of between three and 30 sunlight-harvesting satellites in lunar orbit, each of which would beam infrared laser power to lunar rovers, landers, crewed habitats and science platforms.

The reason? If spacefaring nations are going to learn to live on the moon, explore it thoroughly and mine resources like water ice in some of the deepest, darkest polar craters, they must overcome one of the celestial body's lesser-known and least attractive talents: its unfortunate propensity for killing lunar surface missions after two weeks.

At issue here are the unique lunar dynamics. The same side of the moon always faces us on Earth, but the moon rotates relative to the sun, which is why night slowly creeps over its surface each month. No spot receives more than about 14 Earth days of sunlight before it's plunged back into darkness (and permanently shadowed regions of the craters around the south pole never receive sunlight).

And therein lies the problem. As the lunar night sets in, temperatures plummet from daytime's approximate peak of 120 degrees Celsius to a decidedly frigid minus 133 degrees. In the permanently shadowed regions of some craters, it's minus 246 degrees, night or day. At such temperatures, spacecraft batteries and electronics embrittle and fail and cannot survive unless enough electrical power is kept in reserve to power "WEBs" — warm electronics boxes — for thermal control.

But extra power means extra batteries, and at a cost of $1 million per kilogram of payload delivered to the moon, that is a rarely available luxury, says Paolo Pino, chief technology officer and a co-founder of Volta, who spoke to me by video.

"When that long lunar night comes, you start having trouble. Temperatures are so low that everything freezes," he says. "All of the missions that have been to the moon recently, with very few exceptions, have struggled with that, and they have died. So, you have this $200 million asset landing on the moon and then dying in two weeks."

▲ The first spacecraft to land near the lunar south pole, India's Chandrayaan-3 lander, operated on the lunar surface until night enveloped it 12 days after landing. The lander was photographed by the rover it deployed to measure the composition of lunar rocks and dust. Volta plans to beam light to future landers and rovers so they can survive the night.

Indian Space Research Organisation

He's referring to the three robotic landers that touched down on the moon between August 2023 and January 2024: India's Chandrayaan-3; Japan's Smart Lander for Investigating Moon, or SLIM; and Texas-based Intuitive Machine's IM-1. Chandrayaan-3 and IM-1 perished immediately as the sun set, while SLIM held on for a time, reviving at sunup three times before its systems succumbed to the punishing cold.

Pino and his colleagues believe it doesn't have to be this way. In October at the annual International Astronautical Congress in Milan, they revealed that Volta has been building and ground testing technology for a moon-specific variant of space-based solar power technology.

Plans call for the constellation, named LightGrid, to initially comprise three 300-kilogram smallsats, rising to as many as 30, with all of them orbiting the moon at an altitude of 100 kilometers. Each smallsat would harvest solar energy with low-cost, commercial off-the-shelf solar panels.

These satellites would track the positions of any surface rover or lander that requested a power injection and then transmit energy via a steerable infrared laser to the LightPort, a Volta-built photovoltaic power receiver, fixed on top of it. The energy received then would help drive surface operations, keep critical electronics warm and/or charge batteries, rather than letting the machine freeze and fail.

Powering lunar assets this way, says Pino, has advantages over using heat from decaying nuclear power sources in a radioisotope thermoelectric generator, as NASA's Curiosity and Perseverance

In this illustration, a laser beam (depicted in violet and blue tones) strikes one of Volta's LightPort receivers. In actual operation, the infrared laser would be invisible because its light does not have the energy to stimulate photoreceptors in the human eye. Volta has conducted multiple tests with 10-by-10-centimeter versions of LightPorts but plans to attach larger versions to surface landers and rovers.

Volta Space Technologies

Mars rovers do. First, the LightPort offers five times the specific power — that is, power per unit mass — of an RTG, and provides "many hundreds of watts" against the 110 watts from a freshly fueled RTG. Second, because RTGs require controlled nuclear materials, they face supply-chain problems, handling restrictions, regulatory challenges, safety issues and the need for radiation shielding on the spacecraft, says Pino.

"It's a great tech, but it comes with a lot of limitations," he says of RTGs.

That's not to say that Volta's alternative doesn't present a raft of multifaceted engineering challenges for its research and development team. These include developing the energy-beaming laser capable of producing a nondiverging infrared power beam; an accurate tracking system capable of pointing the laser at lunar surface assets from a fast-moving satellite; and development of the LightPort.

The LightGrid architecture calls for an 1,800-watt, 50-centimeter-diameter power beam, for which Volta is developing — partly with a grant from the Canadian Space Agency — an infrared fiber laser and telescopic optics to generate and collimate the beam to keep its energy tightly focused and nondiverging, says Pino.

"High-power lasers, especially in space, have had some troubles with radiation as well as with temperature extremes, so we have had to craft a system capable of dealing with those issues."

To achieve the required resilience, an optical fiber is chemically doped to cope with the thermal and radiation environments expected near the moon. A semiconductor laser diode launches infrared light into the fiber to generate the beam. In a series of ionizing radiation dose tests, which Volta undertook at "a specialized and certified radiation test facility in Europe" in 2023 and 2024, the engineering model of the laser suffered only a 5% performance degradation after exposure to 18 kilorad. That's the equivalent to a decade's worth of cislunar radiation.

The laser engineering model is now at Technology Readiness Level 6, on the scale used by NASA and the U.S. military to assess technology, says Pino. "It cleared all its major environmental tests, including radiation, shock and vibration, thermal vacuum, life test and thermal cycling."

But by late 2026, when the company hopes to run the laser in power beaming tests from a test satellite in low-Earth orbit to the ground, it will need to be at TRL 9, he says — in other words, ready for orbital action.

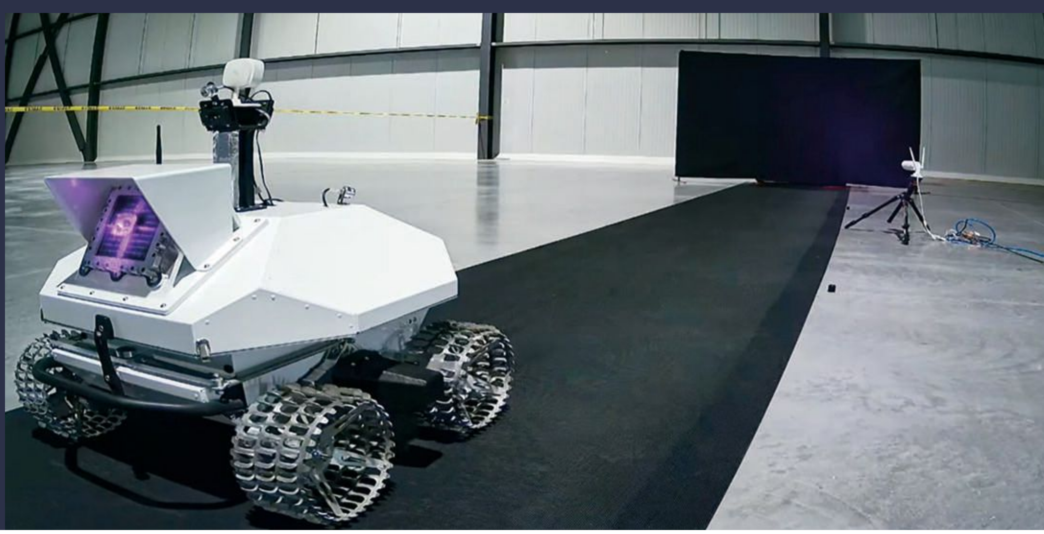
Volta in late January issued a request for proposals for the spacecraft that will fly the test laser.

"We've been talking to several satellite bus providers in the last few months, and we would like to make our decision super early in the year to partner and go ahead and fly," says Pino.

Building the laser is one thing, but aiming its 50-cm-diameter beam at the lunar surface from a moving satellite is quite another. The satellite and the laser unit will need to maneuver to do this.

"The satellite changes attitude, but our system also has an internal pointing and tracking system," Pino says.

In June, Volta began laser optical alignment tests on farmland at Saint-Michel, south of Montreal. "We tested the alignment across 800 meters, the idea being to really make sure that we can propagate and send



Among Volta's latest tests of its power-beaming technology was this one in November, in which an infrared beam was directed onto the LightPort receiver affixed to this lunar rover prototype, built by Canadensys of Ontario. The rover's batteries were able to be recharged.

Volta Space Technologies

photons with very, very good precision," says Pino.

Having learned from that how to improve the laser's optics and thermal load handling, they then attempted some limited target tracking at a lower range. The reason? "Outdoors, a bunch of factors play against power beaming as we optimize it for lunar applications, like the atmosphere, humidity and wind," Pino says. "So, we had to work at a smaller distance to see how everything behaves, accomplishing some tracking at about 170 meters with a receiver that was moving side to side, 20 to 30 centimeters, on a gantry."

In November, tests were moved indoors to an industrial warehouse at Beauharnois, southwest of Montreal. Here, a newer model of the laser projected a beam at a mini lunar rover prototype, 200 meters away, to which a 10 cm by 10 cm LightPort receiver was affixed. This experiment, using a rover built by Canadensys, an Ontario-based aerospace firm, "demonstrated the receiver could push power into the battery, recharge the battery and support operations on the rover," says Pino.

For actual lunar operations, Volta plans to build a larger variant of LightPort, measuring 30 cm by 30 cm, to receive the 50 cm beam. The whole LightPort assembly has a mass of 2 kg and will initially provide power of 100 watts — more if customers want it.

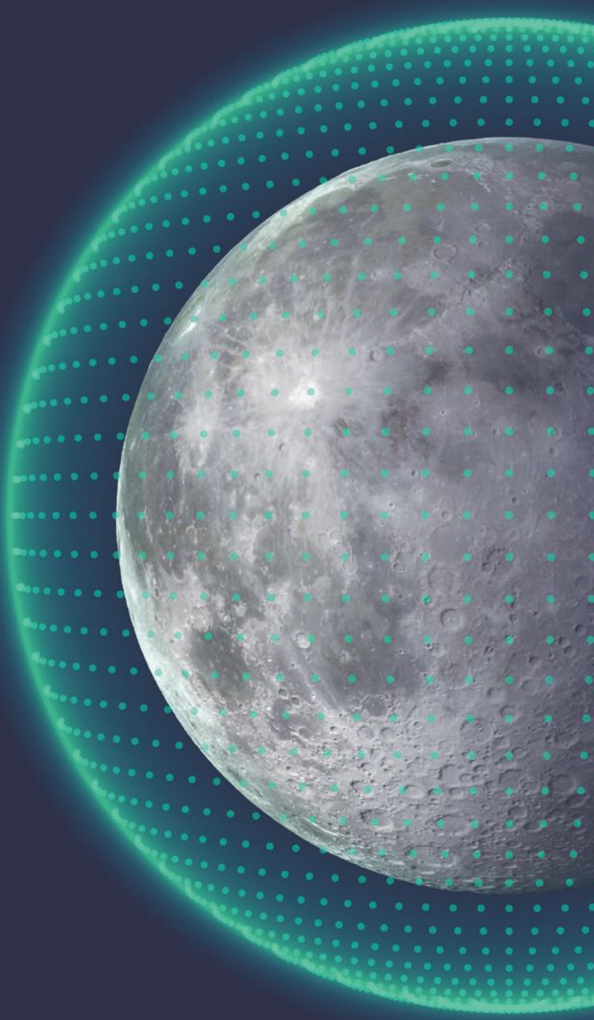
As a LightGrid satellite sweeps over the lunar horizon at an altitude of 100 km, its IR laser scans the area where it expects the lunar rover or lander to be. Once triggered, the LightPort radios a "you got me" acknowledgment signal back to the satellite. The spacecraft then maintains track of that asset and begins sending a four-minute burst of power via the laser. Then, additional satellite passes provide still more power.

"We think that starting with just three satellites gives customers a charging window every 40-ish minutes or so," says Pino. "That's the minimum viable constellation, as we call it."

He adds: "The 30-satellite constellation is kind of an end vision that allows us essentially to deliver constant coverage to a particular area. A customer at the south pole, where we expect most of the activity to take place, will see a satellite at any time."

“You have this $200 million asset landing on the moon and then dying in two weeks.”

— Paolo Pino, Volta Space Technologies



Whether Volta’s plans come to fruition depends in large part on customers being willing to pay for their power-as-a-service offering. The commercial signs are good, the company says. Expressions of interest have come in from companies planning to mine the permanently shadowed craters and canyons of the south polar region.

One company has also struck a firm deal with Volta: ispace-U.S. of Denver wants the LightGrid to provide a “survive the night” capability for its planned lunar surface science and in-situ resource utilization projects. Technologies that “enable survival in extreme lunar environments are crucial for a permanent human presence on the moon,” says ispace-U.S. CEO Ron Garan.

Space technology consultant John Mankins of San Luis Obispo, California, who specializes in studying space-based solar power architectures, thinks Volta’s technology sounds feasible.

“Their biggest dilemma is going to be their business model: A lot of companies have entered this sector, planning to offer laser power delivery from space to space, or from space to the ground, over the last four years. Can they get out in front and be first? We’ll see.”

First or not, the need for lunar survive-the-night technology is becoming pressing. In January, Firefly Aerospace’s Blue Ghost lunar lander was launched, carrying 10 NASA instruments. Plans call for five hours of operation into the lunar night on battery power, says marketing director Risa Schnautz. “This is primarily to collect data on how the hardware performs in the lunar night environment.”

“Firefly is working toward its own survive-the-night capability, and that’s something we’ll support as required by our payload customers,” she says.

Space-based solar power is very much a live issue, 84 years after Asimov envisioned it.

“When you look into space-based solar power, what you always see are pictures of giant spacecraft requiring assembly in orbit, that require multiple launches, and on launchers that don’t yet exist,” Pino says. “So, what Volta is trying to do here is to switch to a different paradigm where we’re saying this is really possible now.

“It’s not sci-fi anymore.” ★

TWO LAUNCHES TWO COMPANIES TWO BILLIONAIRES

The debut of Jeff Bezos' New Glenn rocket design vividly illustrated the contrast between Blue Origin's "step by step, ferociously" approach and the "break it till you make it" philosophy that Elon Musk and SpaceX have embraced for the Starship-Super Heavy vehicles. Cat Hofacker analyzes the competing approaches, their origins and what's at stake.

BY CAT HOFACKER

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Blue Origin's New Glenn design and SpaceX's Starship-Super Heavy vehicles are famously competing to open the space frontier to human exploration by NASA and settlement by others, but for Bezos, there is nearer-term potential benefit.

One is a possible shift in market momentum from SpaceX to Blue. "They've got the latecomer advantage," says Chris Combs, an aerodynamics professor at the University of Texas at San Antonio who watches the two programs closely. He's referring to that quirk of technology development that could permit Blue to master booster landing and reuse more quickly than SpaceX did with its Falcon rockets, by learning from SpaceX's mistakes. The first Falcon booster landing came on the design's 20th flight, but Combs predicts that Blue could easily land a booster within 10 flights.

New Glenn's debut also brings the design a step closer to being certified by the U.S. Space Force to launch large spy and military satellites. SpaceX has enjoyed a near monopoly on these national security launches with its Falcon fleet, but soon the U.S. might find itself with three competitors: Blue Origin with New Glenn, SpaceX with Falcons and United Launch Alliance, whose Vulcan Centaurs were under final certification review by Space Force as of late January.

Blue's entrance into the competition, as much as anything, demonstrates that SpaceX's methods aren't the only way to make an entirely new class of rocket. When the first New Glenn lifted off in the early morning of Jan. 16 at Cape Canaveral and boosted its demonstration payload to medium-Earth orbit, the breakthrough culminated at least 10 years of research and testing without any exploding launch pads or "rapid unscheduled disassembles," as SpaceX calls vehicle explosions.

Which is not to say that Blue doesn't know test failures. The company crashed two New Shepard boosters in the years leading up to Jan. 16, but those occurred in the safety of its test range, an uninhabited expanse of desert near Van Horn, Texas.

In New Glenn's debut, the booster's data transmission fell silent during its return to Earth, and it did not achieve the hoped-for landing on the recovery barge, Jacklyn, named for Bezos' mother. The barge sailed home empty to Port Canaveral from the Atlantic Ocean, north of the Bahamas.

The contrast in developmental approaches was vividly demonstrated 15 hours later, when the seventh Starship-Super Heavy lifted into the afternoon sky from Boca Chica, Texas, on a mission to test the first Block 2 Starship, a revised upper stage. With larger propellant tanks and other upgrades, this Starship was supposed to be the first one to deploy payloads, specifically, 10 simulated Starlink satellites that like Starship would be placed on suborbital trajectories. Instead, SpaceX lost contact with the ship roughly 8 minutes into the flight, and within an hour, videos on social media showed debris streaking earthward over the Turks and Caicos Islands. FAA said later that it diverted dozens of flights and was "working with SpaceX and appropriate authorities to confirm reports of public property damage." In the following days, multiple photos and videos on X showed what appeared to be chunks of Starship on beaches and a golf course.

The Super Heavy booster, though, headed back to the pad and lowered itself to achieve the second "chopstick" capture by the launch tower. Such is spaceflight: New Glenn reached orbit, but its booster was lost. Starship did not reach orbit, but its booster made it back intact.

Musk shrugged off the latest Starship loss, joking on X: "Success is uncertain but entertainment is guaranteed!"

For him, the loss of the vehicle was not a failure but a quick way to find out if there was a problem with the upgraded design so that it could be fixed. Musk followed up on X to say that early analysis pointed to "an oxygen/fuel leak in the cavity above" Starship's six Raptor engines that caused a fire.

For Blue Origin, based in Kent, Washington, New Glenn's drama-free deployment vindicates its "gradatim ferociter" — "step by step, ferociously" — slogan that encapsulates its approach to technology development. Blue decided early on to master suborbital flight with a vehicle one-fifth the size of New Glenn. The start was rough. The first New Shepard rocket, an unoccupied vehicle, crashed during its inaugural flight in April 2015. But on the second try seven months later, Blue launched and landed the booster and its unoccupied capsule. It then repeated that feat 14 more times before launching its first passengers in 2021.

In total, Blue has launched New Shepards 28 times and landed the booster in all but two of those flights. In both cases, engine issues caused a loss of control. New Glenn's debut showed that Blue has yet to master the technique at a much larger scale.

As different as the approaches of Blue and SpaceX are in terms of risk acceptance, they are both examples of iterative design, in which products are incrementally refined, says Combs, the aerodynamics professor.

"What's novel about the SpaceX approach is they're much more willing to do full-scale iterative design," he says. "You can collect a lot of data that way. You can learn a lot of things."

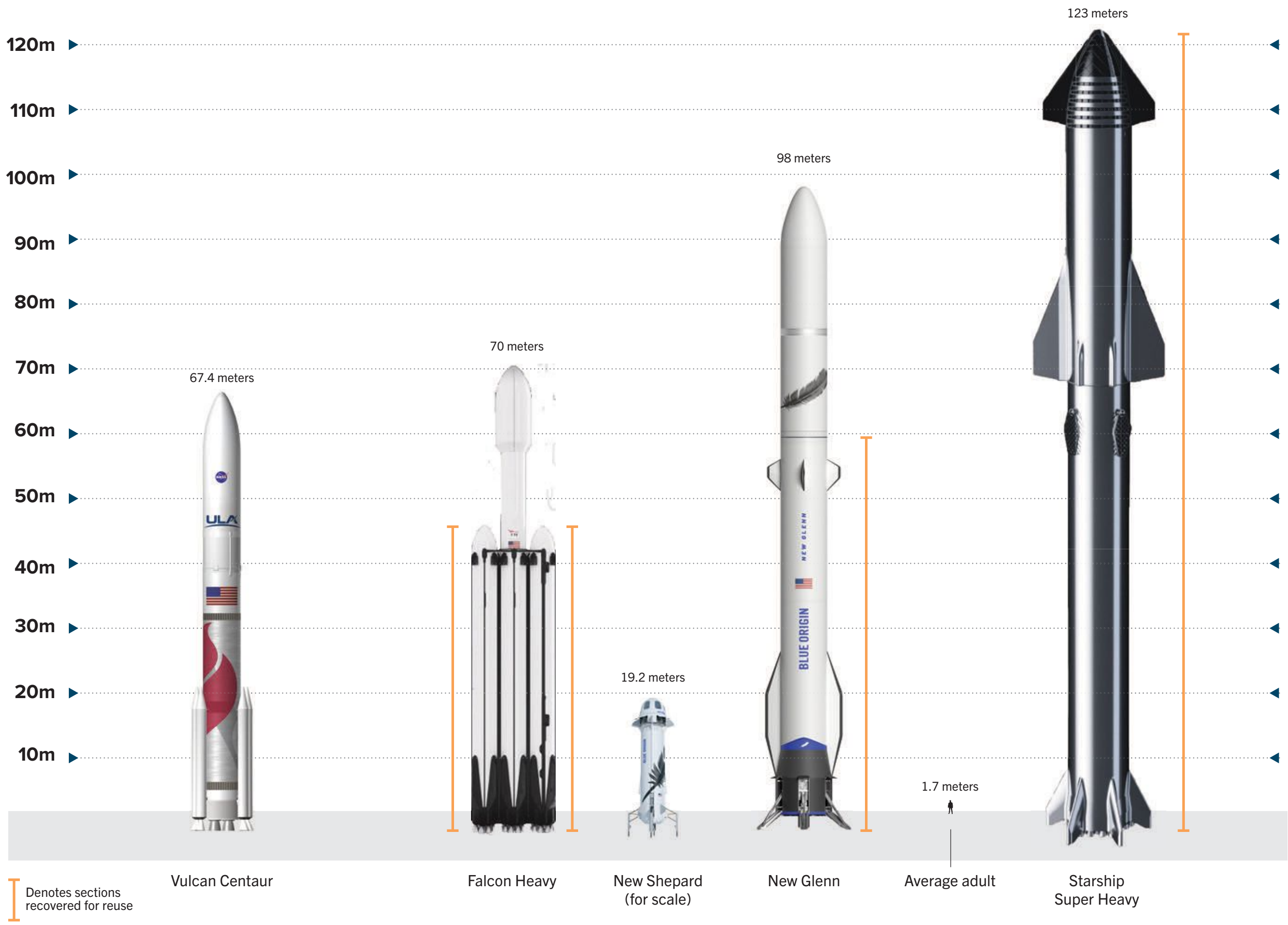
However, he adds, blowing up dozens of multimillion dollar vehicles is "a real luxury that very few organizations can actually afford. When you're backed by the richest person in the world, that helps."

Of course, Bezos is the second richest, so in theory, Blue could choose to do the same but has not.

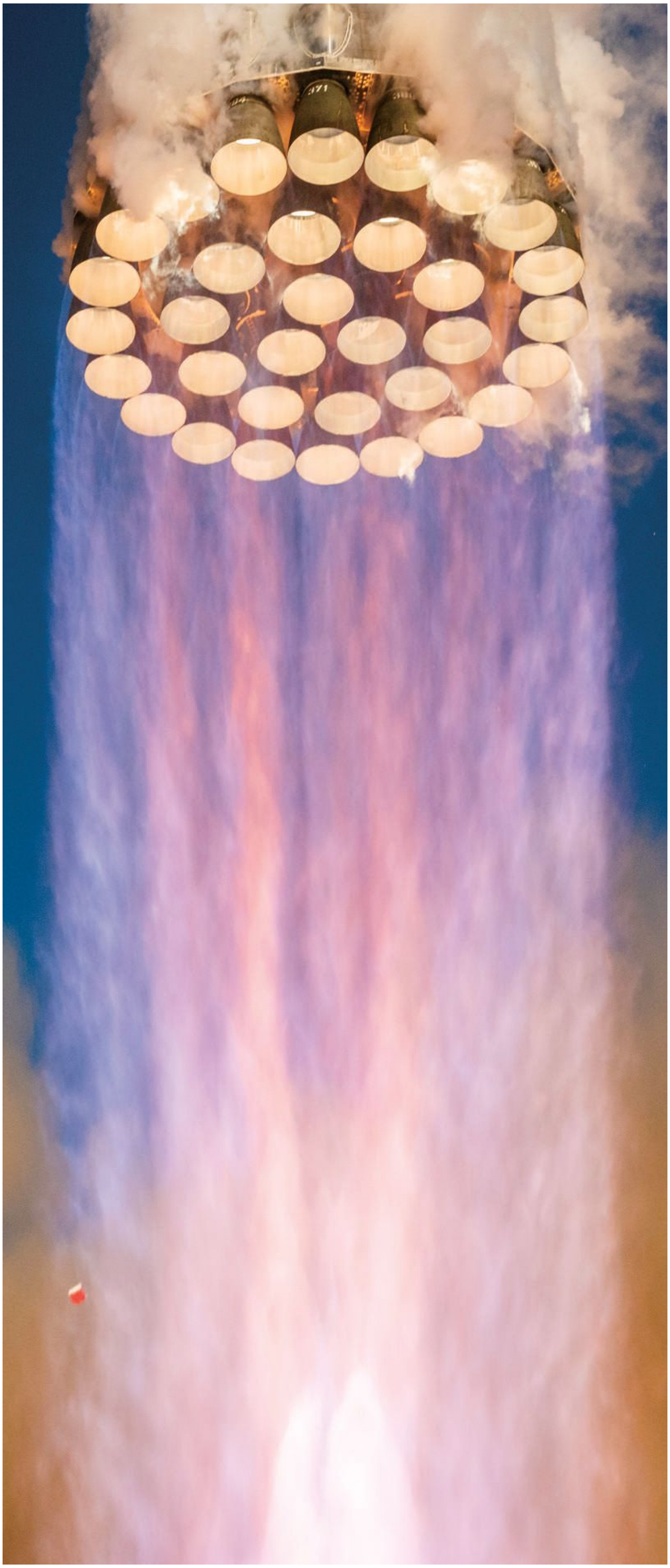
The Starship explosion has had literal and figurative fallout: Musk's "'fail and fail often' philosophy isn't bold innovation — it's reckless disregard for the

The heavy-lift competitors

A customer who needs to launch more than 20 metric tons to orbit could soon have three rocket designs to choose from. Once fully certified, New Glenn and ULA's Vulcan will compete against SpaceX's Falcon Heavy to launch U.S. spy and military satellites. NASA is counting on New Glenns and Starships for its Artemis lunar landing program.



	PROPELLANT	FAIRING DIAMETER	PAYLOAD CAPACITY	PRICE PER LAUNCH
Vulcan Centaur	First stage: liquified natural gas fuel and liquid oxygen oxidizer, augmented by up to six solid rocket boosters (shown with four) Second stage: liquid hydrogen and liquid oxygen	5.4 meters	**LEO:** up to 25.8 metric tons **To the moon:** up to 11.5 metric tons	Declined to say. Analysts estimate $100-112 million
Falcon Heavy	Both stages propelled by liquid hydrogen fuel and liquid oxygen oxidizer	5.2 meters	**LEO:** up to 63.8 metric tons **To the moon:** up to 16.8 metric tons	$150 million if fully expendable
New Glenn	First stage: liquified natural gas and liquid oxygen oxidizer Second stage: liquid hydrogen and liquid oxygen	7 meters	**LEO:** 45 metric tons **To the moon:** declined to say	Declined to say, but $68 million according to a 2022 analysis
Starship-Super Heavy	Both propelled by liquid methane fuel and liquid oxygen oxidizer	9 meters	**LEO:** 250 metric tons if expendable **To the moon:** 100 metric tons after refueling in LEO	Elon Musk has said "maybe" as low as $2 million



planet and its people," wrote Moriba Jah, an astrodynamicist and Aerospace America columnist, in a LinkedIn post. "This attitude reeks of arrogance and privilege, especially when the failures of these ventures, often framed as learning opportunities, come at the expense of the environment, public safety, and global livelihoods."

SpaceX did not respond to requests for comment, but a portion of the company's post-launch statement posted on its website seemed aimed at addressing such public safety concerns: "Starship flew within its designated launch corridor — as all U.S. launches do to safeguard the public both on the ground, on water and in the air. Any surviving pieces of debris would have fallen into the designated hazard area."

While SpaceX often describes its approach as the best way to quickly make progress, that might not always hold true. Combs notes that Blue Origin's version of iterative design requires a longer development stage, but "it can potentially be more efficient" in the long run. "If things go well with the full-scale flight testing and things work within the first handful of tries, it's going to be way faster to go that way."

He notes that a Starship has yet to attempt to complete an orbit of Earth. All seven Starship-Super Heavy flights have followed suborbital trajectories so that SpaceX can practice and refine landing techniques for both stages, among other objectives. Three Starship upper stages have made controlled splashdowns in the Indian Ocean, and two Super Heavys have flown back to the launch site for capture in the tower's chopstick arms.

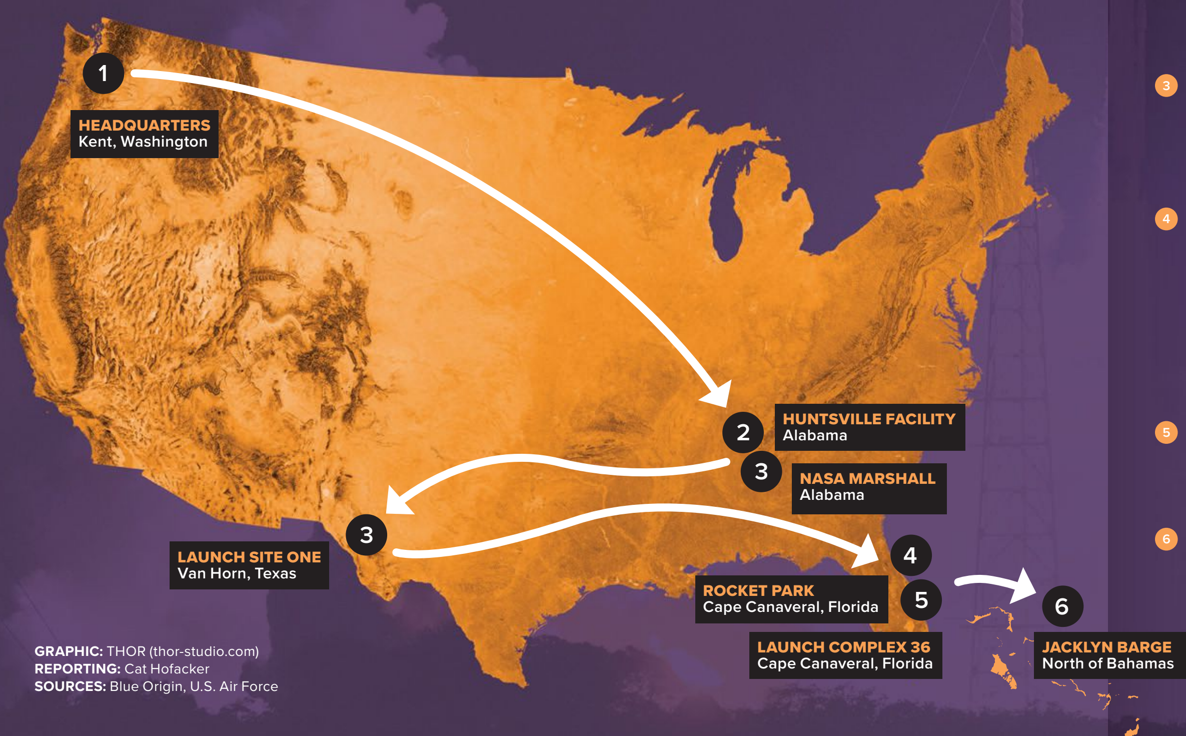
Shortly after last month's flight concluded, FAA ordered SpaceX to investigate the loss of Starship and provide a report describing "corrective actions" that must be completed before the next vehicle flies. This is the design's fourth grounding. Blue, due to the loss of the booster, must also complete a mishap investigation and submit a report to FAA to receive its launch license for New Glenn's second flight. Blue says it's targeting "spring" for that launch. Ever optimistic, Musk said on X that he believes the next Starship could be launched in February.

Though there is heady competition between Blue and SpaceX, the two rockets are not equally matched in payload capacity. New Glenn is targeting 45 metric tons — double what Falcon 9 can send to low-Earth orbit but less than Falcon Heavy's 64 metric tons. Starship would dwarf them all, with its 9-meter-diameter fairing designed to carry 100 metric tons in reusable mode, and up to 250 in expendable.

But until Starship begins commercial operations, New Glenn's 7-m-diameter fairing may be the best option for customers whose spacecraft don't fit in the roughly 5 m fairings of Falcons and ULA's Vulcan Centaurs, or who are looking to launch more spacecraft at a time.

The first New Glenn: from design to launch

Readying Blue Origin's heavy-lift launch vehicle for its inaugural flight on Jan. 16 required a decade of design, testing and manufacturing.



1. **Engine design**
   BE-4 booster and BE-3U upper stage engines conceived here.
2. **Engine manufacturing**
   Seven BE-4s and two BE-3Us made here.
3. **Testing**
   Engines and subsystems tested in Alabama and Texas.
4. **Rocket manufacturing and assembly**
   Booster, upper stage and fairing built and assembled at a facility outside of NASA's Kennedy Space Center.
5. **Launch Complex 36**
   Final preparations for the launch.
6. **Booster recovery**
   Telemetry was lost and booster was not recovered.

GRAPHIC: THOR (thor-studio.com)
REPORTING: Cat Hofacker
SOURCES: Blue Origin, U.S. Air Force

◀ In the seventh Starship-Super Heavy flight last month, SpaceX recovered the Super Heavy booster but the Starship upper stage exploded.

SpaceX

In the near term, Blue has contracts to launch satellites for commercial megaconstellation builders in addition to competing for the national security launches. Longer-term plans call for ferrying cargo and NASA astronauts to the moon under the Artemis program. At this writing, Starship's advertised roles are to launch Starlinks, deliver astronauts and cargo to the moon for NASA, and someday fulfill Musk's dream of sending 100 people at a time to Mars. SpaceX hasn't said if it will submit Starship for national security missions, but the U.S. Space Force is reportedly interested in studying how the design might be used to ferry large amounts of cargo.

Despite their many differences, New Glenn and Starship share an emphasis on reusability. That feature is partly tied to affordability, but it's also driven by the personal ambitions of the company founders. Bezos proposes creating colonies in low-Earth orbit where millions would live and work, and Musk frequently talks about establishing a "self-sustaining" city on Mars. Both visions require the ability to frequently launch large amounts of crew and cargo in one go. Rockets designed to launch and land over and over would be the best way to achieve this.

Of course, with Blue's "slow and steady" pace also comes increased expectations from customers, says Ryan Puleo, an analyst with Virginia-based BryceTech. Indeed, up until this point, development of New Glenn was more step by step than ferocious. The debut was originally scheduled for 2020 but was repeatedly delayed, partly due to challenges in developing the BE-4 booster engines. Those delays were compounded by Blue's contractual obligation to deliver the first BE-4s to ULA for the Vulcan boosters. However, this brought a small upside: ULA launched two Vulcans in 2024, allowing Blue to see the BE-4s in action before New Glenn's flight.

If past is prologue, that extended development phase could recede quickly into memories, if Blue concludes the investigation and is permitted to return to flight expeditiously. Hardly discussed today are the three extra years it took to achieve New Shepard's first passenger flight, the 2021 flight to the fringes of space with Bezos and three others.

James Muncy, a Virginia-based space consultant, welcomes the arrival of a "competitive marketplace" but cautions against trying to judge each company's approach against the other. "We'll find out what works, and what works for one of them probably wouldn't have worked for the other, and vice versa." ★

THE BIG QUESTION

"Will geostationary satellites one day become obsolete given the proliferation of satellites in low-Earth orbit?"

In the span of six years, Elon Musk's Starlink internet constellation has shattered the near-total dominance of large satellites in geosynchronous equatorial orbit, or GEO, as the means for delivering internet services from space. SpaceX's Starlink subsidiary now has roughly 7,000 satellites in low-Earth orbit, and last year, it reportedly surpassed 4 million subscribers around the globe. Starlink's success has sparked interest in LEO beyond internet services. The Pentagon is getting into the action with the Space Development Agency's Proliferated Warfighter Space Architecture, a planned constellation of hundreds of communications and missile tracking satellites in LEO. **With all the interest and investment flowing toward LEO satellites, I asked five experts if the days of GEO satellites are numbered.**

BY JON KELVEY | jonkelvey@gmail.com

Mark Dankberg

Chairman of the Board, CEO and co-founder of Viasat, the California-based operator of 19 GEO communications satellites founded in 1986.

○ YES ● NO ○ MAYBE

“Geostationary satellites are by far the most economically efficient for national or regional usage.”

— Mark Dankberg

Absolutely not. GEO satellites will remain an integral component of satellite networks. There are different advantages to different orbits.

Geostationary satellites are by far the most economically efficient for national or regional usage. Geostationary satellites are licensed by about 60 different nations around the world. Most of those countries use their satellites for national or regional communications applications. Often those same countries look at ownership and control of their space systems as fundamental for national sovereignty and/or security.

LEO satellite networks are inherently global and offer lower latency. But while orbital, spatial and spectrum sharing regulations are mature and successful at geostationary orbits — such regulations are virtually nonexistent on a global basis for nongeostationary orbit (NGSO) satellites in what is essentially a zero-sum game sharing environment. Such regulations are necessary not only for GEO-LEO coexistence but also for coexistence among the LEO networks of multiple nations.

U.S. domination of LEO is likely not sustainable, with U.S. licensees only accounting for about 20% of global geostationary satellite licenses and over 65% (and climbing rapidly) of nongeostationary orbit satellites. There are plans and/or pending applications for tens of thousands of additional LEO satellites, such as the planned 13,000-satellite Chinese Guowang constellation. There are substantial concerns regarding space sustainability and coordination of orbital, spatial and spectrum resources in the absence of sharing regulations.

The United Nations’ International Telecommunication Union, ITU, has emphasized in statements that the orbits and radio frequency spectrum necessary for satellites to operate are finite natural resources that must be shared and protected. Given the critical nature of sovereign space assets in the current geopolitical environment, and the economic superiority of modern high-throughput satellites in geostationary orbits for national and regional applications, and the recent statements from the ITU regarding resource sharing, we expect that geostationary satellites will continue to be an essential component for commercial, civil and national security applications for countries worldwide — even as more and more countries add NGSO components to their networks.

Viasat is working closely with both global LEO and regional GEO satellite operators to integrate hybrid multiorbit, multiband satellite communication networks to deliver the benefits of each for civil, commercial and national security missions consistent with globally shared and sustainable orbital resources.

Tim Farrar

Founder of Telecom, Media and Finance Associates Inc., a Menlo Park, California-based research and consulting firm.

○ YES ● NO ○ MAYBE

Geostationary satellites will not become obsolete. But they will likely decrease in importance over time, and there will be less motivation to upgrade these satellites as they become confined to a backup role. The clear success of Starlink despite early skepticism has highlighted the potential advantages of using LEO once a satellite operator gains sufficient scale. The problem is that smaller operators (and even many of the major legacy GEO operators) don’t have the vast resources of companies like SpaceX and Amazon and so can’t keep up with the investment required to build and maintain a cutting-edge LEO network.

The Starlink constellation has grown rapidly since the first test satellites were launched in 2018, growing to more than 6,000 satellites today. As SpaceX maintains a regular schedule launching more and newer Starlink satellites, the company has rapidly grown its capacity throughput: Starlink has demonstrated it can deliver massively more capacity than existing GEO satellite-based communications services and with lower latency. Viasat recently posted on X that its in-flight connectivity service can handle connecting 50 million passengers a month. Assuming (optimistically) 1 gigabyte per passenger, that works out to around 50 petabytes of data each month — roughly what Starlink carries each day.

Take terrestrial consumer broadband as another example. The average U.S. Viasat customer pays around $115 per month for about 50 GB of data, while the average U.S. Starlink customer pays $120 per month for 300 to 400 GB of data. And we see that same higher capacity in other parts of Starlink’s business, such as maritime connectivity, with the typical customer using five times as much data over Starlink compared with GEO services such Inmarsat.

Across all its services, Starlink provides data with much lower latency. This may not matter for all customers. But it’s worth noting that over the past 20 years of mostly failed attempts at bringing in-flight connectivity to the masses, passengers have repeatedly complained that the experience was like drinking through too small a straw.

"Just because Starlink offers greater capacity doesn't mean every customer will abandon their GEO vendors overnight, or even ever, if they don't need much data and GEO service is adequate for their needs."

— Tim Farrar

But while Starlink is the market pioneer, other players are trying to chase Starlink's success in LEO. OneWeb already offers internet broadband services, though its 600-satellite constellation cannot compete with Starlink in capacity, and even the second-generation system planned for the early 2030s is unlikely to close this gap. The vast resources that Amazon has committed to its Project Kuiper satellite broadband constellation makes it the most plausible competitor to Starlink, and it will begin launching satellites aboard ULA, Arianespace and Blue Origin launch vehicles in early 2025. Given that GEO operators are struggling to get their newest generations of GEO satellites in orbit on schedule — and they are further hampered by not simultaneously operating a launch service like SpaceX — they will face stiff competition from the rapidly growing LEO services.

But just because Starlink offers greater capacity doesn't mean every customer will abandon their GEO vendors overnight, or even ever, if they don't need much data and GEO service is adequate for their needs.

For example, credit card verification at gas stations has continued to rely on older GEO satellites for the past couple of decades. But when it comes to in-flight connectivity, airlines will have to decide if they can afford to offer the service to their customers for free to distinguish themselves from the competition. Easy to use, high-quality, free service is what Starlink is emphasizing, but it comes at a significant cost to the airline. So the billion-dollar question in the industry right now is whether passengers will choose to fly a particular airline because it has Starlink Wi-Fi rather than Viasat Wi-Fi, so airlines will be forced to upgrade their service to retain market share. We haven't seen much evidence of that yet. But it is still early days, and some airlines like United Airlines clearly hope that Starlink will provide them with a significant level of differentiation in the marketplace.

Daniel Goldberg

CEO and president of Telesat, the Ottawa-based satellite communications company that since 1979 has provided TV and telephone services using a constellation of GEO satellites. Telesat plans to add services with a LEO constellation, Telesat Lightspeed.

YES NO MAYBE

GEO will not become entirely obsolete. I do believe that LEO, given the performance advantages it offers in terms of lower latency and a much more distributed, resilient network, will become the preferred architecture for broadband connectivity requirements.

The customer community — whether it's consumers or enterprises — see huge performance benefits in LEO services. Recently, United Airlines and Air France announced they are transitioning from their GEO networks to using Starlink for in-flight Wi-Fi connectivity. And Starlink has made significant inroads in the maritime and consumer broadband connectivity markets, with over 4 million subscribers.

Many GEO satellite operators and service providers are partnering with LEO operators to complement their existing satellite infrastructure. Viasat, for instance, recently announced it is in discussions with Telesat for LEO capacity and has also partnered with Eutelsat OneWeb for maritime multiorbit connectivity offerings.

"Starlink has certainly validated how powerful LEO is, and we believe our Telesat Lightspeed broadband internet network will be a competitive, transformational alternative for enterprise, telecom, government, aviation and maritime customers."

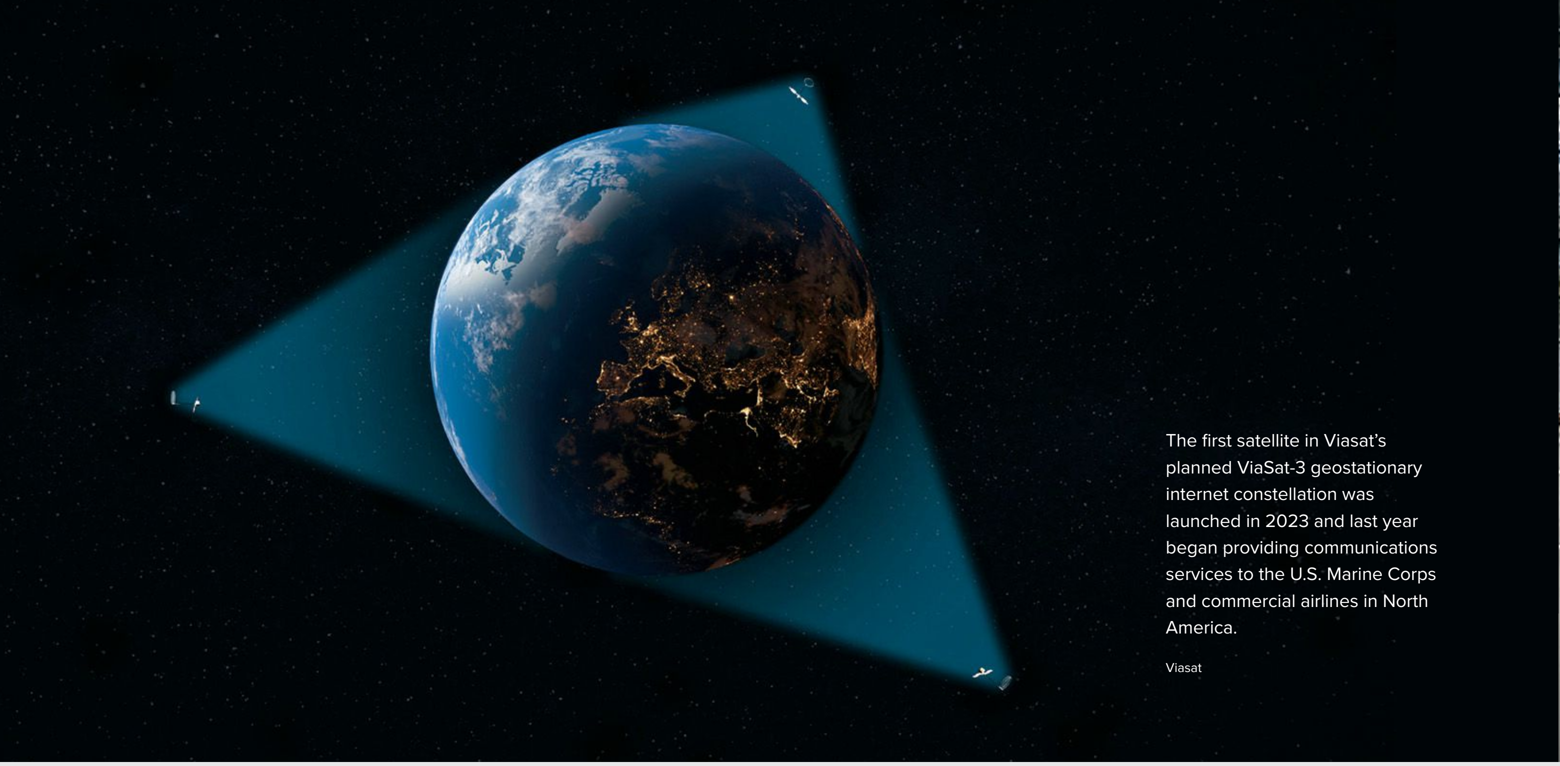
— Daniel Goldberg

SpaceX has launched nearly 7,000 of the 12,000 satellites that are to comprise its initial Starlink broadband constellation. SpaceX

Starlink has certainly validated how powerful LEO is, and we believe our Telesat Lightspeed broadband internet network will be a competitive, transformational alternative for enterprise, telecom, government, aviation and maritime customers. Unlike LEO networks that were designed primarily for best-effort consumer broadband connectivity, the Telesat Lightspeed has unique capabilities for enterprise customers, including committed information rates and service level agreements, multi-Gbps [gigabytes per second] data links, and complete control on the services delivered to each of its sites. Telesat is now in the engineering and manufacturing phase of the project, and we expect to begin launching our LEO satellites in mid-2026 and begin beta testing shortly thereafter, with global services commencing in late 2027.

There likely will be some user segments that will value the benefits of a multiorbit offering of GEO and LEO, including government users who prize network resiliency. The U.S. Department of Defense, for instance, is moving away from using a handful of easily targeted GEO satellites for communications, missile tracking and other services. Its Proliferated Warfighter Space Architecture network will rely on a new constellation of many small military satellites in LEO while also integrating existing commercial LEO constellations as part of the architecture. The Telesat Lightspeed network was designed from inception to achieve a high cybersecurity rating under the U.S. Space Force Infrastructure Asset Pre-Approval program and to be interoperable via optical laser links under the Space Development Agency's standards. GEO will continue to be the most efficient distribution option for direct-to-home broadcast networks and television distribution, albeit this is no longer a growth segment in most parts of the world due to cord-cutting. Certain networks in tropical or harsh weather environments will likely maintain C-band links for network resiliency, whereas UHF and X-band payloads in GEO will remain valuable to defense users.

I believe GEO will have a role to play in the future — but most broadband connectivity requirements will be better served by low-latency LEO networks.



The first satellite in Viasat's planned ViaSat-3 geostationary internet constellation was launched in 2023 and last year began providing communications services to the U.S. Marine Corps and commercial airlines in North America.

Viasat

Karan Kunjur

Co-founder and CEO of K2 Space Corp., a Torrance, California-based company formed in 2022 to focus on reducing the cost of GEO communications satellites.

YES **NO** MAYBE

GEO satellites are not currently competitive with LEO constellations, but I don't think it's a problem intrinsic to GEO. It's a problem with the way we're using GEO.

Spending $700 million to build and launch a GEO satellite is no longer competitive with new LEO constellations. The first step to innovating around that challenge is to bring down the cost of GEO satellites, and that previously has only come from shrinking them. But smaller satellites present a problem: less power.

Power determines throughput, and smaller GEO satellites today generate less than 5 kilowatts of power compared to the 20 kilowatts of traditional exquisite GEO satellites. If you pay $300 million for a communications satellite that only gives you 5 kilowatts of throughput, the business case doesn't close on a dollar-per-megabit basis.

We founded K2 Space in 2022 with a goal of reducing the cost of building GEO satellites with more power, taking advantage of what we call "the new era of mass abundance." We've watched the success of launch vehicles like Falcon 9 push launch costs down, and Starship and Blue Origin's New Glenn are set to reduce the cost of mass to orbit even more. So we've designed our Mega Class satellite with a 20-kilowatt bus. At $15 million and the ability to stack three GTO (geostationary transfer orbit) satellites in a launch vehicle, we think the unit economics of GEO start to make sense again. Our next model, the Giga Class, will be a 100-kilowatt bus. But we're not building big satellites for GEO just because new launch vehicles make it possible. We believe there are important advantages to GEO.

First, unlike SpaceX and Kuiper, most operators don't own their own launch vehicle. We think those operators will find it almost impossible to deploy a LEO constellation at scale and make the business case close.

> "If you pay $300 million for a communications satellite that only gives you 5 kilowatts of throughput, the business case doesn't close on a dollar-per-megabit basis."
>
> **— Karan Kunjur**

Second, you can more quickly deploy greater capacity in GEO to target a service area. Doubling the capacity of my LEO constellation over a region requires doubling the size of the entire constellation, requiring multiple launches. To double my capacity over a specific market at GEO, I only need to put up a second satellite in that GEO slot.

And the higher you go, the fewer satellites you need for global coverage and the fewer launches you need. With less expensive, more capable satellites, we envision a multiorbit future with layers in LEO, MEO and GEO, all with their own use cases and customer segments.

The white rectangle at the front right is a Starlink terminal installed on a Hawaiian Airlines Airbus A321neo. Last year, the airline began offering free Starlink Wi-Fi to passengers. Hawaiian Airlines

Chris Quilty

Co-CEO and president of Quilty Space, an industry research and analytics firm based in St. Petersburg, Florida.

YES ● NO MAYBE

GEO satellites will not become obsolete, but GEO communications have probably passed their heyday.

I have to admit that when SpaceX and OneWeb announced in 2015 that they were building LEO constellations, I was skeptical. Almost a decade later, my conclusions have almost flipped entirely. It now appears that for many or most applications, a sufficiently scaled LEO constellation can provide better service across almost every attribute compared to GEO constellations.

Take maritime communications. A standard GEO antenna weighs more than 200 kilograms and costs $25,000 or more. Alternatively, a sailor can carry a Starlink antenna aboard under their arm for $2,500. The GEO antenna will deliver data rates of 20 megabits per second at best, while Starlink provides 100 to 200 Mbps, and with 50 milliseconds latency compared to the 800 ms for a GEO satellite system.

Putting performance aside, the GEO industry also faces challenges in terms of capacity and timing. It took Viasat seven years and reportedly about $700 million to design and build its latest satellite, the ViaSat-3, and so far, only one of the planned three satellites is in orbit — the satellite serving North America launched in the spring of 2024 and experienced an antenna issue that reduced its capacity by 90%.

Companies such as California-based Astranis and Switzerland's SWISSto12 have begun developing smaller GEO satellite alternatives to the multiton warhorses common in GEO. The idea is to fly a relatively larger constellation of cheaper, smaller GEO satellites to save costs and speed production. But LEO constellations like Starlink have a significant head start. Even if GEO was toe-to-toe competitive with LEO today, supply chain issues would make matching LEO constellations in capacity difficult.

> "It now appears that for many or most applications, a sufficiently scaled LEO constellation can provide better service across almost every attribute compared to GEO constellations."
>
> **— Chris Quilty**

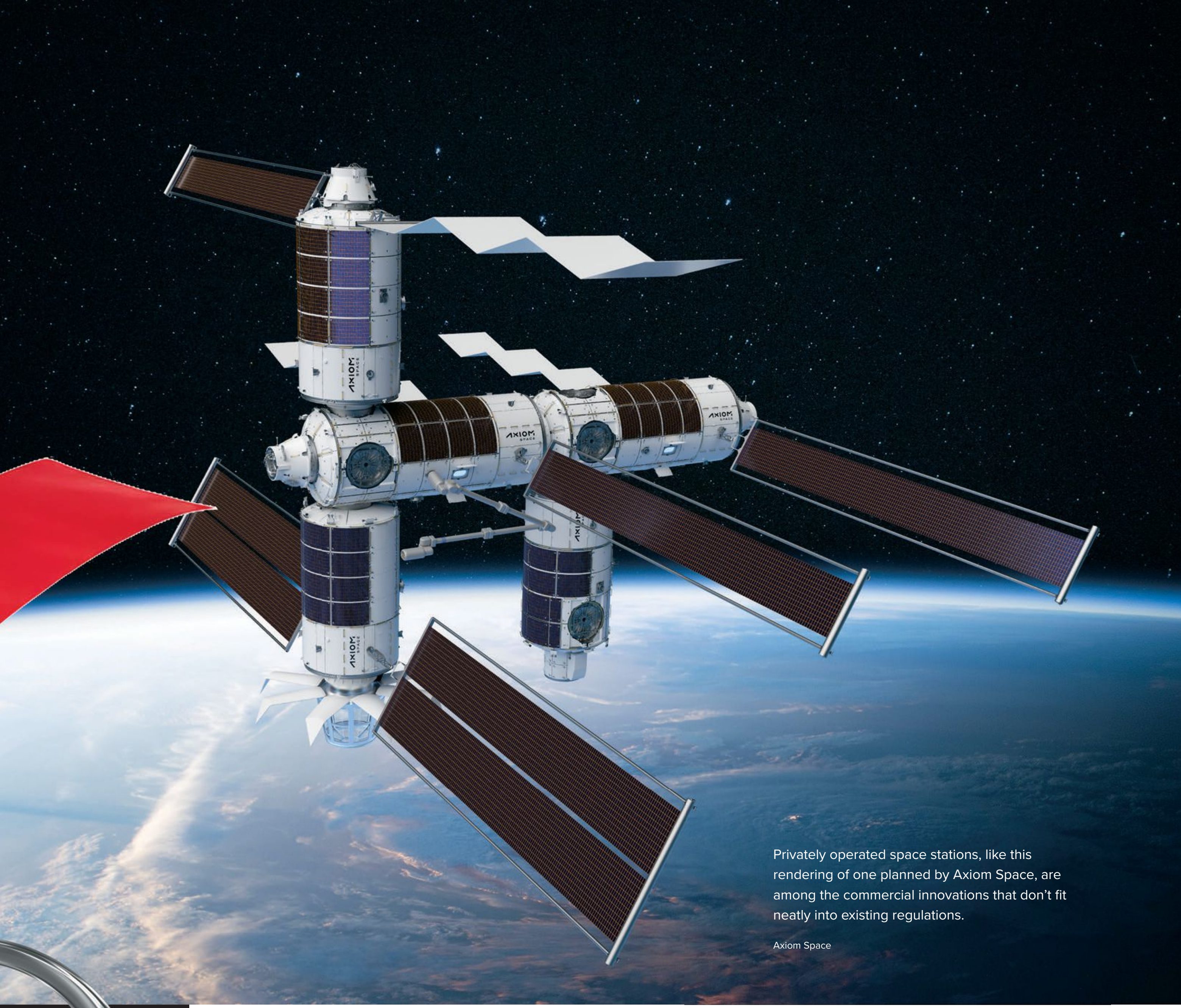
But GEO satellites do offer some advantages over LEO. There are areas of the globe, such as China, where access to the internet is tightly controlled, and consumers are not permitted to access Starlink. That leaves GEO services — mostly Chinese owned — as an alternative. And by virtue of their high altitude, GEO satellites are less affected by space debris or geomagnetic storms, like the one that pulled more than 40 newly launched Starlink satellites from orbit in 2022.

Large maritime vessels still retain their GEO antennas, even as they shift most of their operation requirements over to the LEO system. The iconic "R2D2" dome isn't going away anytime soon, but its role is quickly shifting to that of a backup system. ★

How the United States can keep leading in space

Today's U.S. space innovators and those to come deserve a regulatory framework that doesn't crimp their agility and encourages them to stay in the country. Veteran commercial space advocate Courtney Stadd explains.

BY COURTNEY STADD



Privately operated space stations, like this rendering of one planned by Axiom Space, are among the commercial innovations that don't fit neatly into existing regulations.

Axiom Space

Every day seems to bring forth a new commercial space venture promising to offer yet another innovative product or service for possible civil, commercial or defense uses. The catalyst for much of this has been SpaceX. The success of Starship's novel, cost-saving "chopsticks" booster capture technique suggests that the capability to launch large payloads, including human passengers at scale, into Earth orbit and beyond may be edging closer to reality. Now, Blue Origin has successfully orbited a test spacecraft with its New Glenn rocket, a vehicle that has been engineered with the safety and redundancy required to fly humans in mind.

All this has excited much media interest and the public's imagination regarding the future of humanity in the cosmos. But the harsh reality is that the federal bureaucracy has proved to be profoundly inadequate at fostering a market-based, agile regulatory model that can meet basic public safety, environmental and security concerns while facilitating the continued emergence of the commercial space domain that NASA and the Department of Defense are increasingly dependent upon.

In 1984, the Commercial Space Launch Act that I helped draft was signed into law by President Ronald Reagan. It created a regulatory framework that encouraged the development of the then-fledging commercial launch industry. Forty years later, U.S. regulations for launching rockets and operating satellites require regulators to pore through the finest details of the licensee's technology and operating plans, resulting in months of uncertainty and significant costs as the launch applicant awaits approval.

An example of how absurd the regulatory process has become came in September, when SpaceX found itself facing a fine for allegedly launching Falcon 9 rockets in 2023 without proper approval from FAA. The company had reportedly moved forward with launches before FAA had signed off on key infrastructure updates, including a new control room and construction of a propellant farm, and the removal of a requirement for a launch readiness poll. It was never clear how directly relevant the ancillary updates were to the actual launch approval.

It might be tempting for government policymakers to extend this type of highly demanding, prescriptive regulatory framework to fill a long-known void in the 1967 Outer Space Treaty. It states that "the activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty," but it did not provide details about how this should be done, and that left a lingering gap in the regulatory landscape.

The Biden-Harris administration, in late 2023, succumbed to the temptation to expand today's conventional regulatory framework to fill that void in the Outer Space Treaty, at least for companies operating in the U.S. The White House National Space Council released a legislative proposal that would require commercial enterprises to obtain "Mission Authorizations." These would be bifurcated between the departments of Commerce and Transportation. Commerce would oversee the authorization of novel space ventures, such as in-space servicing, while FAA's Office of Commercial Space Transportation (part of the Transportation Department) would oversee all commercial crewed missions to orbit.

One of the first actions of the Trump administration should be to rescind this legislative proposal and replace it with hard law that establishes a process for a self-governance model by commercial enterprises. Here's why: Doing so would avert an entirely "hard law" approach to overseeing activities in space. The consulting firm Deloitte, in its July 2024 white paper on the topic, "Rockets and Regulation: Injecting Agility into US Space Industry Oversight," argues for applying "soft law tools" to fill gaps left by hard law. Indeed, what's needed is a flexible, agile governance approach. Doing so would unleash today's novel commercial space ventures to open up the full economic potential of space, whether in Earth orbit, at the moon or beyond. Innovative companies based in the U.S. would not feel they have to leave our nation in order to open up the space frontier.

The latter is not an idle threat. An example of a company partly relocating overseas is OneWeb, a satellite internet company that registered in the U.K. in 2012 due to burdensome regulations here in the U.S. The company's decision to be headquartered in the U.K. and use European launch vehicles (such as those from Arianespace) highlights the challenges faced by U.S.-based companies when trying to compete globally under stringent U.S. export controls and licensing regulations.

What do we mean by innovative? Not that long ago, commercializing space meant operating privately owned communications and imaging satellites. Now, entrepreneurs and innovators are planning to set up habitats and space stations for commercial customers. Some want to sweep up debris to help the space environment. Others are pursuing in-space servicing and repair missions and planning to create orbiting fuel depots. They represent companies that, metaphorically speaking, are square pegs that do not

SpaceX in January landed a Super Heavy booster back at the launch tower in Boca Chica, Texas, for the second time. The mission was the seventh flight of a Starship-Super Heavy rocket since 2023, and the first with an upgraded version of a Starship upper stage.

SpaceX

“What’s needed is a flexible, agile governance approach. Doing so would unleash today’s novel commercial space ventures to open up the full economic potential of space, whether in Earth orbit, at the moon or beyond.”

fit easily into the round holes represented by the current federal licensing regime. On that point, operators of communications satellites are licensed by the Federal Communications Commission, and imagery satellite operators are licensed by NOAA. That leaves a host of potential operations that do not fit into those categories.

This nascent space industry could be greatly impeded if the government were to establish overly restrictive policies and regulations.

I propose market-based collaborations that will foster flexible, agile governance approaches based on overarching boundaries, such as not putting the public at unnecessary risk, creating environmental hazards or violating national security. Within those broad strictures, industry would be encouraged to form consortia that would focus on best practices regarding, for example, removal of orbital debris or protocols regarding technical issues such as pressure per square inch levels within spacesuits and capsules and habitats to facilitate emergency rescue of foreign astronauts.

Here are some examples of possible industry-led self-governance models in various domains:

- Groups could identify technical standards for communication, transportation and energy systems, ensuring compatibility and safety across different operations.
- Developers of commercial space habitats could form associations to standardize construction materials, safety protocols and operational procedures, ensuring all structures meet a specific level of quality and safety.
- Firms engaged in lunar mining for Helium-3 or rare Earth elements and other resources could establish industry standards for extraction practices, environmental protection and resource sharing. Just as we have witnessed in the oil and gas industry, a consortium could be set up to set overall guidelines.
- Companies could adopt voluntary codes of conduct for sustainability and ethical practices, promoting responsible exploration and development in a way that could influence market behavior.

In the business world, there is an axiom: Always work backward from your customers’ needs. To be competitive in the global market, U.S. space commercial firms must be laser focused on innovation and speed to market. They should not have to leave our nation to innovate. It’s time for U.S. policymakers to work backward from what they are witnessing: a growing commercial space sector that, in collaboration with the government, is capable of self-governance in certain key domains while it seeks the most favorable regulatory environment that balances concerns regarding public safety, environmental hazards and national security while minimizing burdensome regulatory reviews and needless red tape. ★

Courtney Stadd is executive vice president of the Beyond Earth Institute, a Washington, D.C., space policy think tank.

The talent solut right in front of

The United States is not creating enough domestic aerospace talent to meet the industry's demand. Plenty of non-American students at U.S. universities are eager to stay after graduation and contribute to the country's economy, but relatively few employers take them up on it. What's blocking the way? Misperceptions about the law are a big part of the problem. Young-Young Shen, Antoine Paletta and Robert C. Winn explain.

BY YOUNG-YOUNG SHEN, ANTOINE PALETTA AND ROBERT C. WINN

ion that's you

Young-Young Shen co-founded AIAA's International Students and Professionals in Aerospace working group in 2023. He is a guidance, navigation, and control engineer at MDA Space in Brampton, Ontario, Canada. He holds a Ph.D. in aerospace engineering sciences from the University of Colorado Boulder.

Antoine Paletta co-founded AIAA's ISPA working group in 2023 with Young-Young. He is a Canadian and French dual citizen and a flight dynamics engineer at Loft Orbital in Toulouse, France. He holds a master's degree in aerospace engineering from Georgia Tech.

Robert C. Winn is a mechanical and forensic aeronautical engineer and principal emeritus of Engineering Systems Inc. based in Colorado Springs. He has been an expert witness in numerous aircraft accident legal actions. He was a U.S. Air Force instructor pilot and taught aeronautical engineering at the U.S. Air Force Academy. He holds a Ph.D. from Colorado State University and is an AIAA fellow.

The U.S. Bureau of Labor Statistics reported in 2015 that the U.S. aerospace industry suffers from chronic worker shortages "due to citizenship and security clearance requirements." This shortage persists and shows no signs of abating. The Aerospace Industries Association predicted in 2023 that "finding enough qualified talent to support demand growth amid retirements" will be "one of the biggest risks executives face" for years to come.

In other industries, such shortages are addressed by hiring foreign workers to fill the gap. In the aerospace industry, however, employers have not rushed to hire the many non-American graduates of aerospace engineering programs in the United States, to the detriment of both the industry and these graduates.

Consider Antoine Marin, a specialist in cislunar mission architectures and a friend of the authors. He came to the United States from France in 2022 and graduated from Georgia Tech in 2024 with a master's degree in aerospace engineering.

"When I came to the U.S., I thought, 'OK, I'm going to explore all the possibilities here — everything looks so open,'" says Marin. However, he soon learned that, because he was not a "U.S. person" — a term referring to U.S. citizens, permanent residents, and certain refugees and asylees — employment possibilities were few and far between. This was despite the fact that as a STEM student, he would have had authorization to work in the U.S. for up to three years on his student visa once he graduated. Ultimately, he found no relevant job openings among those listed as available to non-U.S. persons. So, he decided that his best option was to return to France.

Or Riccardo Calaon, also a friend of ours. He came to the U.S. from Italy in 2021 to pursue a Ph.D. in

aerospace engineering sciences at the University of Colorado Boulder. His reasons for coming went beyond professional development.

"I consider myself to have had the American Dream," says Calaon. "I wanted to do a Ph.D. in the U.S. to open up more opportunities for myself [and] work on things I'm interested in that I didn't get to work on back home. But I also wanted to live in the U.S. for a while and experience the culture there."

An accomplished scholar who counts among his accolades the prestigious U.S. Fulbright scholarship along with numerous other internationally and nationally recognized scholarships and fellowships, Calaon was unable to secure a job offer in the U.S. In some cases, conversations with employers would seem to stop abruptly as soon as he disclosed his non-U.S. person status. And he could not simply become a U.S. person — doing so could require years of paperwork and typically requires sponsorship from a U.S. employer in the first place.

As his graduation date neared, Calaon began to apply for jobs back home. "As soon as I started looking in Italy, it felt like companies were throwing jobs at me."

Calaon returned to Italy in September 2024 and finished the requirements for his degree remotely.

Marin and Calaon are not alone. Approximately 50% of students enrolled in engineering graduate programs in 2022 were not U.S. persons, according to data compiled by the Council of Graduate Schools. Many of them, like Calaon, graduated with doctoral degrees. Only a small handful of those engineers who majored in aerospace succeeded in finding job placements in the U.S. in their major field of study. The remainder likely returned to their home countries after finding out late in their educational journeys that they were trapped in a catch-22: Most employers in the U.S. aerospace industry are unwilling to hire them because they are not U.S. persons, but becoming a U.S. person requires employer sponsorship. That is a lot of talent that was nurtured in the U.S. but did not end up helping the U.S. aerospace industry.

It is true that American defense contractors are very limited in who they can hire due to security clearance requirements. However, many of those in the country's aerospace industry don't do work that requires a clearance. Also, a common misconception is that the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations

▲ In one example of the aerospace industry's demand for workers, Boeing in 2024 estimated that the commercial aviation industry will need 674,000 new pilots, 716,000 new maintenance technicians and 980,000 new cabin crew members.

Boeing

(EAR) prohibit regulated businesses from employing foreign nationals. In reality: "Neither the ITAR nor the EAR outright prohibits a U.S. company in the space industry from hiring a foreign person," says attorney Jack Shelton, a founding partner at Aegis Space Law. "Rather, these regulations provide that before releasing export-controlled information to such foreign persons, the U.S. company might need a license from the State Department or the Commerce Department."

He continues: "In some instances, a license might not even be required, or a licensing exception might be available, depending on the classification of the information to be shared and the nationality or country of permanent residence of the foreign person."

Such licenses are referred to as "deemed export" licenses, because technical data is deemed to have been exported to a foreign person without the data leaving the United States. Applying for and receiving such a license is not nearly as onerous, time-consuming or risky as one might think.

"It involves a bit of paperwork and usually a few months for the government to process," Shelton says.

Often, the turnaround time on a license application is even shorter. In fact, in 2021, an EAR license application took an average of 33 days to process, and in 2022 only 0.6% of the applications were denied a license. There is no fee to apply for a license, except that applying for an ITAR license requires the business to be registered with the State Department, which incurs a one-time nominal fee. Furthermore, in October 2024, the Department of State and the Department of Commerce announced a relaxation of export control rules on a wide range of technologies used in the space industry, including new license exceptions for many such technologies.

Once a license is in place, a number of options exist for a non-U.S. person candidate to obtain work authorization in the U.S., many of which are commonly used by other industries to hire high-skilled foreign workers. These include post-completion Optional Practical Training, or OPT, authorizations, which permit new graduates to work while still on their student visas, or H-1B visas, a common type of work visa. Both of these provide time for the employer and the employee to work together to apply for a permanent residency permit — also known as a "green card" — for the employee, which, when received, grants the employee U.S. person status.

To address this mismatch between demand and supply, Young-Young and Antoine founded the International Students and Professionals in Aerospace working group under AIAA's International Activities Group. Our working group is developing the "Guide to Hiring International Talent in the US Aerospace Industry," to be published by ISPA soon. It will be designed for businesses that would like to gain an advantage in talent acquisition over their competitors by opening their vacancies to the many highly qualified foreign national graduates that would otherwise leave the country every year. It dispels the many myths surrounding employment of foreign nationals and provides guidance and resources for the deemed export licensing process. A growing number of companies are already finding success by employing a diverse, international staff, particularly in the commercial space sector, and the guide will be a blueprint for how other businesses can join them.

The present situation represents a substantial missed opportunity for aerospace businesses and international engineers and graduating students alike. It's time to make regulation-compliant hiring of international talent the norm in the U.S. aerospace industry. ★

Aerospace America **publishes a rich variety of opinions relevant to the future of aerospace. The views expressed are those of the author(s) and do not necessarily reflect those of our publisher, AIAA.**

AIAA Bulletin

DIRECTORY

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

Calendar

26–27 FEBRUARY 2025

Houston, Texas

In this year of transitions — political, strategic, acquisitional, and mission-driven — 2025 ASCENDxTexas will focus on the innovation and adaptation necessary to navigate the evolving space economy. Some of the space industry's most distinguished leaders will lead these pivotal discussions, ranging from policy to commercial challenges and changing timelines. The next giant leap starts here.

ascend.events/ascendx/ascendxtexas

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2025			
3 Feb–21 Apr	Space Flight Physiology Course	ONLINE (learning.aiaa.org)	
4–25 Feb	Fundamentals of Python for Engineering Programming and Machine Learning Course	ONLINE (learning.aiaa.org)	
6 Feb–10 Apr	Atmospheric and Near-Earth Space Environment Course	ONLINE (learning.aiaa.org)	
11–13 Feb	Understanding Space: An Introduction to Astronautics & Space Systems Engineering Course	ONLINE (learning.aiaa.org)	
11–20 Feb	Business Development for Aerospace Professionals Course	ONLINE (learning.aiaa.org)	
12 Feb–16 Apr	Engineering and Operations for Planetary Field Geology Course	ONLINE (learning.aiaa.org)	
18 Feb–13 Mar	Test Foundations for Flight Test Course	ONLINE (learning.aiaa.org)	
21 Feb	AIAA Los Angeles University Student Branches Mini-Conference 2025	Los Angeles, CA	
24 Feb–5 Mar	Technical Writing Essentials for Engineering Course	ONLINE (learning.aiaa.org)	
25 Feb–27 Mar	Electric VTOL Aircraft Design: Theory and Practice Course	ONLINE (learning.aiaa.org)	
26–27 Feb	ASCENDxTexas	Houston, TX	
1–8 Mar*	IEEE Aerospace Conference	Big Sky, MT (www.ieee.org)	1 Jul 24
4 Mar	50th Dayton-Cincinnati Aerospace Sciences Symposium	Dayton, OH (aiaa-daycin.org/DCASS/)	17 Jan 25
4–20 Mar	Wind Tunnel Testing for Aircraft Development Course	ONLINE (learning.aiaa.org)	
5–17 Mar	Cislunar Exploration: Challenges and Opportunities Course	ONLINE (learning.aiaa.org)	

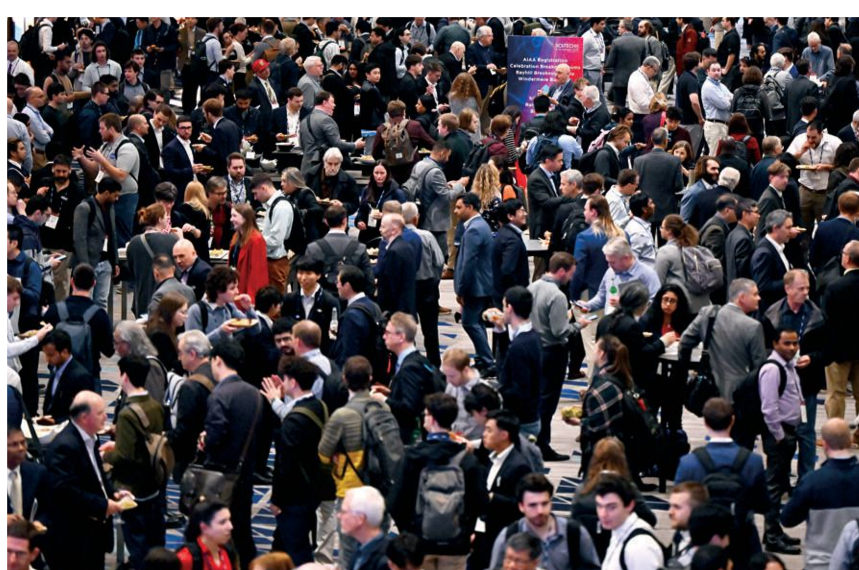
For more information on meetings listed below, visit our website at aiaa.org/events or call 800.639.AIAA or 703.264.7500 (outside U.S.).

DATE	MEETING	LOCATION	ABSTRACT DEADLINE
2025			
10 Mar–16 Apr	Design of Space Launch Vehicles Course	ONLINE (learning.aiaa.org)	
17–20 Mar	Space Mission Operations Course	ONLINE (learning.aiaa.org)	
19 Mar*	HYSKY 2025 H2Hub Summit	ONLINE (www.hysky.org)	
20–21 Mar	AIAA Region I Student Conference	Montréal, Quebec, Canada	10 Jan 25
24 Mar–2 Apr	Digital Engineering Fundamentals Course	ONLINE (learning.aiaa.org)	
28–29 Mar	AIAA Region IV Student Conference	Dallas, TX	31 Jan 25
29–30 Mar	AIAA Region VI Student Conference	Irvine, CA	2 Feb 25
31 Mar–23 Apr	Fundamentals of Structural Dynamics Course	ONLINE (learning.aiaa.org)	
1–10 Apr	Systems Engineering and Artificial Intelligence for Aerospace Applications Course	ONLINE (learning.aiaa.org)	
3–4 Apr	AIAA Region II Student Conference	Greensboro, NC	3 Feb 25
3–4 Apr	AIAA Region V Student Conference	Minneapolis, MN	31 Jan 25
4–5 Apr	AIAA Region III Student Conference	Cincinnati, OH	8 Feb25
10–13 Apr	29th Design/Build/Fly Competition	Tucson, AZ (aiaa.org/dbf)	
15–18 Apr	AIAA DEFENSE Forum	Laurel, MD	15 Aug 24
29 Apr	2025 AIAA Fellows Induction Ceremony and Dinner	Washington, DC	
30 Apr	2025 AIAA Awards Gala	Washington, DC	
21–25 Jul	AIAA AVIATION Forum	Las Vegas, NV	21 Nov 24
22–24 Jul	ASCEND Powered by AIAA	Las Vegas, NV	21 Nov 24
10–14 Aug*	AAS/AIAA Astrodynamics Specialist Conference	Boston, MA (https://www.space-flight.org)	
14–19 Sep*	International Electric Propulsion Conference	London, UK (electricrocket.org)	1 Mar 25
29 Sep–3 Oct*	75th International Astronautical Congress	Sydney, Australia (iac2025.org)	28 Feb 25
3–7 Nov*	COSPAR 2025 Symposium	Nicosia, Cyprus (cospar@cosparhq.cnes.fr)	4 Apr 25

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

● AIAA Continuing Education offerings

From 6 to 10 January 2025, AIAA SciTech Forum gathered more than 6,200 attendees, including 2,000 university students, to learn from 2,900+ technical presentations and explore how we are envisioning and enabling new means of transportation and exploration that will revolutionize society. The Expo Hall showcased 104 exhibitors and sponsors and allowed for great networking conversations.




STUDENT LOUNGE


WHY GO?
SCIENCE
INSPIRATION
NATIONAL POSTURE
SCITECH

AIAA Announces New International Section

AIAA has provisionally chartered a new section in the United Kingdom. The AIAA UK Section is located within Region VII and includes members living in England, Scotland, Wales, and Northern Ireland. The section will be given a one-year period to host events, activities, and programming to ensure it's a sustainable professional section before receiving full charter status.

The addition of the UK Section brings the global total of AIAA sections to 58. Sections are led by AIAA members who volunteer to organize and offer technical programs, networking, educational opportunities, and other activities tailored to local aerospace professionals, students, and educators.

New Student Branches

AIAA is excited to welcome the addition of seven new student branches for provisional charter. The universities include:

- Institut Teknologi Bandung (Indonesia)
- King Abdulaziz University (Saudi Arabia)
- M.S. Ramaiah University of Applied Sciences (India)
- Military Institute of Science and Technology (Bangladesh)
- Southern Illinois University Edwardsville (United States)
- TED University (Turkey)
- University of Luxembourg (Luxembourg)

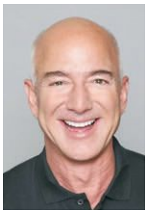
The universities have a three-year period to ensure they are a sustainable branch before being officially chartered as a student branch.

AIAA Announces 2025 Premier Award Winners

AIAA is pleased to announce the 2025 recipients of the AIAA Premier Awards, recognizing the most influential and inspiring individuals in aerospace whose outstanding contributions merit the highest accolades. The awards will be presented during the AIAA Awards Gala on Wednesday, 30 April, at the Washington Hilton, Washington, DC. The Institute also will recognize its Class of 2025 Honorary Fellows and Fellows at the AIAA Awards Gala.

The winners are:

AIAA Goddard Astronautics Award



Jeffrey P. Bezos, Founder, Blue Origin *"For visionary leadership in moving us toward a future where millions of people are living and working in space for the benefit of humanity."*

AIAA Reed Aeronautics Award

Vigor Yang, Ralph N. Read Chair and Regents' Professor, Daniel Guggenheim School of Aerospace Engineering, Georgia Institute of Technology *"For seminal contributions to the understanding of combustion physics in aerospace systems, to technological innovation in aerospace propulsion, and to the advancement of aerospace engineering education and literature."*

AIAA Distinguished Service Award

Basil Hassan, Director, Engineering Sciences Center, Sandia National Laboratories *"For more than three decades of exemplary service at the national, technical, and regional levels, as well as with Publications, Honors and Awards, and the AIAA Foundation."*

AIAA Engineer of the Year Award

Christopher John Ruscher, Vice President and Senior Research Engineer, Spectral Energies, LLC *"For the design, development, integration, and demonstration of a robust pressure sensor on a hypersonic sounding rocket and F404 engine test."*

AIAA International Cooperation Award

Hitoshi Kuninaka, Director General, Institute of Space and Astronautical Science (ISAS) and Vice President, Japan Aerospace Exploration Agency (JAXA) *"For fundamental contributions to electric propulsion and leadership of the world's first asteroid sample return missions, as well as for fostering international cooperation and public interest in space exploration."*

AIAA Lawrence Sperry Award

Gökçin Çınar, Assistant Professor of Aerospace Engineering, University of Michigan *"For pioneering research and innovative contributions to electrified aircraft systems and sustainable aviation."*

AIAA Public Service Award

Bhavya Lal, former NASA Associate Administrator for Technology, Policy, and Strategy, NASA Headquarters (retired) *"For lasting and sustained leadership in national space policy and setting the course for NASA's future missions to the moon, Mars, and beyond."*

Daniel Guggenheim Medal (Sponsored by AIAA, ASME, SAE International, and the Vertical Flight Society)

Stephen W. Tsai, Research Professor, Emeritus, Stanford University *"For foundational contributions to the mechanics of composites over a distinguished 60-year career, resulting in laminate theory and failure criteria that are the basis of modern aerospace composite structures."*

For more information on the AIAA Honors and Awards Program, contact Patricia A. Carr at patriciac@aiaa.org.

MAKING AN IMPACT

AIAA Announces 2025 International Student Conference Winners

AIAA has announced the 2025 International Student Conference winners in partnership with the AIAA Foundation. On 6 January, during the 2025 AIAA SciTech Forum, 20 technical paper first-place finalists from all seven 2024 AIAA Regional Student Conferences and the PEGASUS – Europe Conference presented their research papers related to aeronautics and astronautics.

The International Student Conference is an invitation-only event contained within the annual AIAA SciTech Forum, where first-place winners from each of the previous year's AIAA Regional Student Conferences present their winning papers. They are judged by a panel of AIAA professional members in the undergraduate, master's, and team categories. AIAA Foundation awards a $1,000 cash prize to each category's first-place winner. All participants' papers are published as part of the AIAA SciTech Forum proceedings and become part of the enduring aerospace industry technical archive found in AIAA's. Aerospace Research Central (ARC).

2025 International Student Conference Winners:

Undergraduate Category:

1st Place: "Experimental Investigation of the Impact of Propeller Configuration, Motor Noise, and Sound Reflection on Sound Pressure Level" by Olivia Hilburn, United States Air Force Academy

Master's Category

1st Place: "Performance Characteristics of a Low-Cost Self-Contained Pressure Data Acquisition System" by Nathan Eller, California State Polytechnic State University, San Luis Obispo

Team Category

1st Place: "Lessons Learned from the Launch of a Student-Built LOX/Jet-A Sounding Rocket" by Callum MacDonald, Rithvik Nagarajan, Ethan Heyns, Braden Anderson, Michael Krause, Varun Natarajan, Anthony Otlowski, and Tristan Terry, Georgia Institute of Technology

AIAA SciTech Forum

K-12 Educator Workshop Prepares Educators to Inspire the Next Generation of Students

On Monday, 6 January, AIAA SciTech Forum featured a K-12 Educator Workshop organized by the AIAA STEM K–12 Outreach Committee. For the third year, teachers were invited to gather, network, and hear firsthand from inspiring speakers in their field. Sessions included presenters from ARISS - Amateur Radio on the International Space Station, the Wolfpack CubeSat Dev Team/BLUECUBE Aerospace, Brigantine Community Schools, National Space Society, Reach for the Stars National Rocket Competition, and Civil Air Patrol.

Cost-effective hands-on activities were demonstrated and available for attendees to try out for themselves, while discussions included best practices and advice on navigating grants, scholarships, and educational tools from AIAA and other organizations. Two presenters from Brigantine Community Schools in New Jersey shared details about a Space Day outreach event they recently held at their school, which they organized after they attended the 2024 K-12 Educator Workshop and got inspired.

For more information about future STEM outreach events, email: K-12STEM@aiaa.org.

Technical Committees Spark Interest in Aerospace Among Middle Schoolers

On Thursday, 9 January, AIAA Technical Committee (TC) members attended Walker Middle School in Orlando for their annual STEM outreach event. Organized by the Structural Dynamics TC and Structures TC, the event introduced principles of aerospace engineering to 120 students in 6th, 7th, and 8th grade through hands-on activities.

The excited students passed through seven different demo stations where they got to experience Chladni plates, acoustics tubes and resonance boxes, vibration shakers with vibrating beams, and scale models of airplane wings. The students appreciated hearing directly from the professionals, learning about the presenters' jobs, where they were from, and what they had studied in high school and college to get to where they are today.

All the students took home swag provided by AIAA and a number of generous exhibitors from the AIAA SciTech Forum Expo Hall who gifted giveaways to the kids.

Recognizing Top Achievements

AN AIAA TRADITION

2025 AIAA SciTech Forum
6–10 January 2025
Orlando, Florida

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 October 2024 and January 2025.

PREMIER LECTURES

2025 AIAA Durand Lecture for Public Service

The lectureship, named in honor of William F. Durand, Ph.D., is presented for notable achievements by a scientific or technical leader whose contributions have led directly to the understanding and application of the science and technology of aeronautics and astronautics for the betterment of humanity. Durand was a U.S. naval officer and a pioneer in mechanical engineering. During his remarkable 99-year life, he contributed significantly to the development of aircraft propellers. He was the first civilian chair of the National Advisory Committee for Aeronautics (NACA), the forerunner of NASA.

Kevin G. Bowcutt
Principal Senior Technical Fellow & Chief Scientist of Hypersonics The Boeing Company

Lecture: "The Evolution of Hypersonic Flight Over Seven Decades and the Technical Breakthroughs that Got Us Here"

2025 AIAA Dryden Lecture in Research

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

Tim C. Lieuwen
Regents' Professor, David S. Lewis Jr. Chair, and Executive Director of the Strategic Energy Institute
Georgia Institute of Technology

Lecture: "Future Research Directions in Aero Propulsion and Clean Energy Systems"

EDUCATION AWARD

2024 Abe M. Zarem Graduate Award for Distinguished Achievement in Astronautics

Mohammed Abir Mahdi
Oklahoma State University

Shafi Al Salman Romeo
Oklahoma State University
Paper: Convolutional Neural Network and Homogenization based Hybrid Approach for Lattice Structures

Advisor: Zhao Wei, Oklahoma State University

LITERARY AWARDS

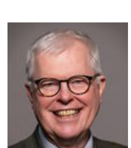
2025 AIAA Gardner-Lasser Aerospace History Literature Award

This award is presented for the best original contribution to the field of aeronautical or astronautical nonfiction literature published in the last five years dealing with the science, technology, and/or impact of aeronautics or astronautics on society.

Michael W. Hankins
Smithsonian's National Air and Space Museum
Book: Flying Camelot: The F-15, the F-16, and the Weaponization of Fighter Pilot Nostalgia

2025 AIAA Pendray Aerospace Literature Award

The award is presented for an outstanding contribution to aeronautical and astronautical literature in the recent past.

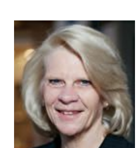


Joseph M. Powers
University of Notre Dame
Book: Mechanics of Fluids

SERVICE AWARD

2025 AIAA Mary W. Jackson Diversity & Inclusion Award

This award recognizes an individual or group within AIAA who has devoted time and effort and made significant contributions to the advancement of diversity and inclusion within the Institute. It also seeks to raise awareness on the value of a diverse membership and inclusive environment, and of important and challenging issues pertaining to diversity and inclusion in the aerospace workforce at large.



Karen A. Thole, University of Michigan
For sustained significant contributions to raise awareness of the value of diversity and inclusion in the aerospace workforce at large, an AIAA core value.

TECHNICAL EXCELLENCE AWARDS

2024 AIAA-AEEE J. Leland Atwood Award This award is bestowed upon an outstanding aerospace engineering educator in recognition of the educator's contributions to the profession. This award is co-sponsored by the ASEE Aerospace Division and AIAA.

Stephen D. Heister
Purdue University
For his transformative impact on the aerospace industry in revitalizing Maurice J. Zucrow Laboratory, and mentoring leaders currently developing advanced rocket and airbreathing propulsion systems.

2025 AIAA-ASC James H. Starnes, Jr. Award This award is presented to recognize continued significant contribution to and demonstrated promotion of the field of structural mechanics over an extended period of time emphasizing practical solutions, to acknowledge high professionalism, and to acknowledge the strong mentoring of and influence on colleagues.

Paul M. Weaver
University of Limerick, Ireland, and University of Bristol, United Kingdom
For his outstanding contribution in the field of composite structures and his supportive and inspirational mentoring of young academics and professionals.

2025 AIAA Aerospace Power Systems Award This award, established in 1981, is presented for a significant contribution in the broad field of aerospace power systems, specifically as related to the application of engineering sciences and systems engineering to the generation, storage, management, and distribution of electrical energy to aerospace power systems.

Margot Wasz
The Aerospace Corporation (retired)
For exceptional technical contributions to advanced spacecraft battery power systems, outstanding service to the mission success of high-value United States Space Force launch vehicle systems, and leadership of AIAA space power activities.

2025 AIAA Air Breathing Propulsion Award This award is presented to an individual for sustained, meritorious accomplishment in the arts, sciences, and technology of air breathing propulsion systems.

Zoltán S. Spakovszky
Massachusetts Institute of Technology
For outstanding and sustained contributions to air-breathing propulsion through rigorous discoveries and advancements in compressor aerodynamic and aerostructural stability and in aeroengine acoustics.

2025 AIAA Ashley Award for Aeroelasticity This award recognizes outstanding contributions to the understanding and application of aeroelastic phenomena. It commemorates the accomplishments of Prof. Holt Ashley, who dedicated his professional life to the advancement of aerospace sciences and engineering and had a profound impact on the fields of aeroelasticity, unsteady aerodynamics, aeroservoelasticity, and multidisciplinary optimization.

Mordechay Karpel
Technion – Israel Institute of Technology
For outstanding contributions to structural dynamics, aeroelasticity, and aeroservoelasticity, including engineering leadership, research innovations, influential publications, development of industrial software, and mentoring of aerospace professionals

2025 AIAA de Florez Award for Flight Simulation This award is presented for an outstanding individual achievement in the application of flight simulation to aerospace training, research, and development.

Heinrich H. Bülthoff
Max Planck Institute for Biological Cybernetics
For groundbreaking research into how the brain processes multisensory perceptual information and the application of this knowledge for developing revolutionary new motion simulation technologies.

2025 AIAA Energy Systems Award
This award is presented for a significant contribution in the broad field of energy systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and conservation of energy.

Ying Zheng
Western University
For remarkable contributions in advancing applied catalysis for clean and renewable energy innovations through exceptional dedication to research, education, and application.

2025 AIAA Hypersonic Systems and Technologies Award This award is presented to recognize outstanding sustained contributions and achievements in enabling technologies and/or the integration of technologies for system applications in the advancement of hypersonic flight.

Gary Polansky
Sandia National Laboratories (retired)
In recognition of decades of technical leadership in pioneering U.S. hypersonic boost-glide vehicle development and testing in service of the national defense

2025 Information Systems Award
This award is presented to recognize outstanding technical and/or management contributions in space and aeronautics for computer, sensing, and fusion aspects of information technology and science.

Radhakrishna Sampigethaya
Embry-Riddle Aeronautical University
For pioneering work and research in aviation cybersecurity in the areas of developing aircraft and air traffic control systems countermeasures, educating the current and next-generation workforce, and enhancing aerospace safety and security.

2025 AIAA Mechanics and Control of Flight Award
This award is presented for an outstanding recent technical or scientific contribution by an individual in the mechanics, guidance, or control of flight in space or the atmosphere.

Ilya Kolmanovsky
University of Michigan
For significant contributions to advances in theory and methods enabling development of reference governors and model predictive control algorithms enforcing safety constraints in aerospace systems.

2025 AIAA Propellants and Combustion Award This award is presented for outstanding technical contributions to aeronautical or astronautical combustion engineering.

Robert P. Lucht
Purdue University
For numerous contributions to combustion, propulsion, and power generation through innovative development of advanced laser diagnostics and applying them to practical energy systems.

2025 AIAA Wyld Propulsion Award
This award is presented for outstanding achievement in the development or application of rocket propulsion systems.

Alon Gany
Technion – Israel Institute of Technology
For pioneering contributions in propulsion research on metalized propellants, energetic materials, hybrid rockets, ramjets, and scramjets, with sustained excellence in educating generations of propulsion experts.

Obituaries

AIAA Fellow Lang Died in November 2024

James D. Lang died on 15 November 2024. He was 82 years old.

Lang graduated from the United States Military Academy in 1963, with a Bachelor of Science in Engineering. Lang pursued advanced studies that reflected his passion for aerospace innovation, earning an M.S. in Aeronautics and Astronautics from Stanford University and a Ph.D. in Aerodynamics from Cranfield Institute of Technology in England.

Lang served in the U.S. Air Force for 25 years. He flew 320 combat missions as a Forward Air Controller during the Vietnam War and was awarded two Distinguished Flying Crosses, a Purple Heart, two Meritorious Service Medals, and 16 Air Medals for his valor and dedication. He served as an Associate Professor of Aeronautics at the Air Force Academy for six years and spent the remainder of his military career at Wright-Patterson Air Force Base Aeronautical Systems Division as an Engineering Test Pilot, Chief of the Avionics Laboratory, and Deputy for Engineering. He retired in 1988 as a Colonel having been awarded the Legion of Merit.

Following his military service, Lang joined Boeing (and McDonnell Douglas) for 11 years of in the roles of chief engineer of the National Aerospace Plane (NASP), the F-15 “Eagle”, and F-4 “Phantom” programs. In 1999 he retired as director of Technology Development in the Phantom Works organization. He served on the USAF Scientific Advisory Board and was recognized as a Fellow of both AIAA and the Royal Aeronautical Society.

After his second retirement he taught in the Aerospace Engineering department at the University of California, San Diego, in addition to acting as Principal Investigator a DARPA flight test program.

A long-time member of AIAA, Lang was a member of the Committee on Higher Education, the Honors and Awards Committee, the Technical Activities Committee, as well as serving on the Board of Directors. He received the AIAA Sustained Service Award in 2001.

AIAA Honorary Fellow Loewy Died in January 2025

Robert G. Loewy died on 3 January 2025. He was 98 years old.

Loewy’s childhood fascination with airplanes led to an extraordinary career that contributed to many revolutionary advances in aerospace engineering. He joined the U.S. Navy’s Officer Training program, which sent him to Cornell University and then Rensselaer Polytechnic Institute (RPI) for his bachelor’s degree, and to MIT for his M.S. in Aerospace Engineering.

Loewy first pursued his professional career in applied engineering at Cornell Aeronautical Laboratories, where he developed a rotary wing unsteady aerodynamic model, a groundbreaking contribution to rotorcraft aerodynamics. This model, referred to as “Loewy’s rotary wing theory,” became a cornerstone for understanding the forces acting on helicopter rotor blades. He then moved to the Vertol Division of Boeing where he rose to the position of Chief Technical Engineer while completing his Ph.D. at the University of Pennsylvania. Loewy was appointed Chief Scientist of the U.S. Air Force under President Lyndon Johnson in 1965, and afterward served as Dean of the College of Engineering and Applied Sciences at the University of Rochester. In 1974, he became Vice President and Provost at RPI, where he founded a Rotorcraft Technology Center of Excellence established by the Army Research Office. After serving as provost, he became the school’s Institute Professor and Director of the Center. In 1993, Loewy assumed the positions of Chair of the Aerospace Engineering School and William R. T. Oaks Professor at the Georgia Institute of Technology, where there is now a library and a lecture series that bear his name. He retired in 2008.

Loewy was elected a member of the National Academy of Engineering for contributions to the engineering of rotary-wing, vertical take-off and landing aircraft, and he was a Class of 1993 AIAA Honorary Fellow. He was recognized with the 1958 Lawrence Sperry Award for his work on rotary-wing aircraft, the 1999 Dryden Lectureship in Research (Avionics: A “New” Senior Partner in Aeronautics), and the 2006 Daniel Guggenheim Medal for pioneering contributions to rotary-wing aeroelasticity and unsteady aerodynamics that had an enormous influence on rotary-wing technology and his contributions to education and public service in aeronautics. Loewy also was a recipient of the Spirit of St. Louis Medal given by ASME and the Nikolsky Memorial Lecturer awarded by the Vertical Flight Society.

An AIAA member since 1944, Loewy was participated in the Institute as a member of the Aerospace Department Chair Association, Honors and Awards Committee, and Applied Aerodynamics Technical Committee. He had been an editor of the AIAA Education Series and an editorial advisor to the *AIAA Journal*.

AIAA Senior Member Yeager Died in 2023

Walter C. Yeager died in 2023 at the age of 87.

Yeager earned his Bachelor of Science degree in Aeronautical Engineering from Purdue University in 1958, and a certificate in Propulsion and Power Conversion from UCLA in 1970. He was a licensed Safety Engineer in California.

Yeager began his 40-year engineering career at Douglas Aircraft in California, where he worked on the liquid oxygen tank vent and relief valve for the Thor missile, and on the design of propulsion for the Skybolt missile. He then spent several years activating Atlas missile bases in Kansas and Nebraska before working on the Nuclear Engine Rocket Vehicle Application project for interplanetary space vehicles at the Bendix Corporation in Indiana.

Returning to California, Yeager worked at Hughes Aircraft on vernier propulsion for the Surveyor spacecraft and thruster rockets for synchronous orbit satellites. The remainder of his career was spent at Garrett AiResearch, which was a subsidiary of the Signal Corporation, and which eventually became Honeywell.

He began work on a business jet advanced turbofan propulsion engine and turbochargers for small aircraft as an engineer. He then became director of Product Integrity and later was a program manager for emergency power and start systems in over 27 aircraft programs, which included the hydrazine F-16 emergency power units and the U2 in-flight start systems. These projects involved travel to Asia, Europe, and the Middle East. After retiring in 1999, he kept busy by doing engineering consulting, pursuing his computer and electronics hobbies, and actively managing his farm in Indiana.

AIAA Senior Member Figler Died in December 2024

Burton D. Figler died on 8 December 2024.

Figler received a bachelor's and a master's degree from MIT in Aeronautics and Astronautics and then an MBA from Northeastern University. Until his retirement, he worked primarily in the field of electro-optics at MIT, Sanders Associates, TechOps, Aerodyne Products Corporation, Honeywell, Lockheed Martin, Loral, and BAE Systems.

Figler was a member of AIAA, National Defense Industrial Association (NDIA), American Army Aviation Association (AAAA), Association of Old Crows (AOD), and Society of Photographic and Instrumentation Engineers (SPIE).

Air transportation sustainability is more than environmental

BY AMANDA SIMPSON | simpson.amanda.r@gmail.com

Coming out of the pandemic, industry leaders in the air transportation sector embraced the idea that their products and services must be "sustainable." This was widely interpreted as a call to reduce or even eliminate the industry's carbon footprint.

This is an understandable sentiment. Webster's defines sustainable as "using a resource so that the resource is not depleted or permanently damaged." We certainly wouldn't want to deplete the atmosphere, but as we set our minds to preventing permanent damage, we must also consider the financial stability and growth of individual companies in the sector. In addition to reductions in carbon emissions, which the industry is working hard to make, other aspects of the industry's sustainability should be considered, because not doing so could make an irreplaceable service for the public falter.

Worth remembering is that air transportation is responsible for a small percent of CO_2 emissions. In 2019, the last year before the pandemic, the sector and other kinds of aviation contributed just 3% of the carbon dioxide released that year, according to "CO2 Emissions from air transport," a paper published by the Organisation for Economic Co-operation and Development, an international policy standards group. Environmental standards and policies must take this relative contribution into account, as the industry seeks to achieve net-zero carbon emissions by 2050. That is an admirable goal, but global market conditions, economics, and public acceptance and engagement will determine if it is realizable in that time frame.

We tend to take flying for granted today, as though transportation preferences are permanently fixed. History tells us they are not. Privately operated passenger trains once crisscrossed the United States. Then, on New Year's Day in 1914, some 3,000 people gathered in St. Petersburg, Florida, and watched an "airboat" take off and skim over the surface of Tampa Bay. This aircraft carried the world's first airline passenger to the Hillsborough River in 23 minutes, a trip that normally would have taken hours, according to an account by the International Air Transportation Association. At first, this futuristic mode of transportation was expensive, but the talents of engineers across many fields made flying more efficient and affordable. Privately operated passenger train services in the United States withered and perished. These were replaced by

Amanda Simpson is a consultant, a former U.S. deputy assistant secretary of defense for operational energy, and a former head of research and technology at Airbus Americas, where she led sustainability efforts. An AIAA fellow, she's a licensed pilot and certified flight instructor.

Amtrak and local municipality-operated trains services.

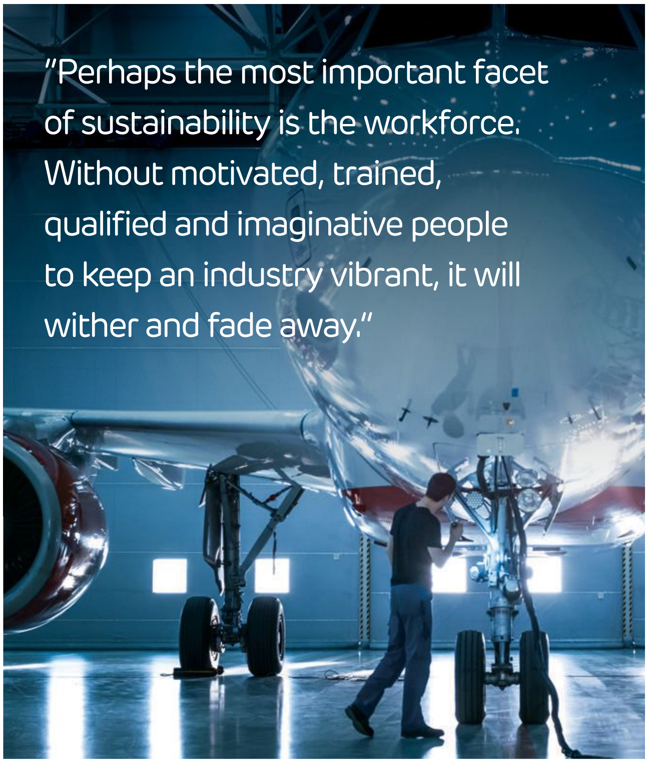
Now, however, the cost curve is in danger of being reversed. Fuel costs are rising. Expensive environmental reviews are required for airport and spaceport expansions. Local jurisdictions can place limits on noise and air traffic growth. Tariffs and taxes are constant hurdles. Environmental sustainability will come at a cost that will be passed along to the consumer. These resulting higher costs could create opportunities for other, yet-unestablished forms of transportation to erode or replace our current air transportation system. Consumers might still prefer flying for speed and comfort but feel as though they have no choice but to shift, given the higher costs. Put simply, today's average passenger might no longer be able to afford to fly to the extent they can now. That would erode the sustainability and stability of the air transportation industry.

Another pillar of sustainability is customer acceptance, which adds up to social acceptance. Challenges could lie ahead for that pillar related to the new, innovative services now in development or in the early stages of introduction. Advanced air mobility developers are working toward certifying electric aircraft for urban and regional transportation. The first drone delivery services have been inaugurated. The return of supersonic commercial travel could be coming.

As exciting as these developments are, they come with risks, including property damage, negative impacts to public lands and waters, and potentially fatal accidents, any of which could sour the currently tenuous public acceptance. A study published in the journal Progress in Aerospace Sciences in 2023, "Public perception of advanced aviation technologies: A review and roadmap to acceptance," found that "missions that support the common good are viewed more favourably than commercial uses such as package delivery or air taxi services." This suggests there will be little public tolerance for commercial accidents that harm property or people.

Recovering from mistakes is hard to do. Consider the Boeing 737 MAX crashes in 2018 and 2019 that killed 346. Even after FAA cleared the MAX planes to return to service, many travelers continued to avoid traveling on these aircraft due to what they perceived as a personal risk to their safety. According to Morning Consult, there remains a tarnished perception of the quality of Boeing products, and this perception was further impacted by the issues associated with the Starliner capsule's crewed mission to the International Space Station. Economic Letter's "Guilt through association: Reputational contagion and the Boeing 737-MAX disasters" details how Boeing's previous reputation as an industry safety and quality leader evaporated within a matter of several years.

While this negative perception has not extended into a loss of consumer trust of the entire air transportation industry, it does demonstrate the fragility of that trust. Trust and social acceptance extend beyond safety to the bold economic and access promises made by those developing the new kinds of services. The public continues to ask: Where is the flying car I was promised? When is that drone arriving with the online purchase I made a few minutes ago? When will lunar mining revolutionize manufacturing and make my life more affordable? When will I get to travel to Mars?



But perhaps the most important facet of sustainability is the workforce. Without motivated, trained, qualified and imaginative people to keep an industry vibrant, it will wither and fade away. Today, careers in air transportation compete with the wealth of the information technology industry, the steady growth of the health care and medical devices market, the excitement of cybersecurity, and the burgeoning artificial intelligence industry that lure away not only college students but also youth who at an early age begin to set their sights on their future. Decades ago, aerospace was the hot career, but according to Federal Reserve Economic Data, aerospace employment plummeted at the end of the Cold War in the 1990s. The latest evidence suggests that while the percentage of engineering majors has remained steady since then, this is not enough to keep up with the demands for workers in the aerospace sector, including air transportation. The U.S. Bureau of Labor Statistics projects a 6% employment demand increase over the next decade, faster than the average for all other occupations. This demand must be met if the industry is to remain viable into the future.

Those of us who have spent decades in the aerospace ecosystem can help by sharing the unique satisfaction that comes from reaching a project milestone, proving that a concept can meet technical objectives and watching the product of our labors ascend into the sky. It's not fast and it's not easy, but it has unprecedented rewards. ★

Homo sapiens: making us suited for the stars

BY MORIBA JAH | moriba@utaustin.edu

Reality has not changed in the years since the space community was jarred by the video of NASA astronaut Drew Feustel struggling to walk after 197 days in orbit: Homo sapiens species are not meant to live in a free-fall environment like orbit or on a lower-gravity body like Mars or the moon. Feustel's wobbly, tentative steps epitomized the physiological toll that space inflicts on Earth-evolved bodies. No matter how much we dream of inhabiting the moon, Mars or beyond, our biology and evolution have firmly tethered us to our home planet — and that's OK. Attempting to equip Homo sapiens with life support equipment for long-term survival in space is not just misguided; it is a colossal waste of resources better spent understanding our limitations and preparing for a more realistic future for our species.

The effects of the curvature of space-time that we call gravity have been the ever-present architect of life on Earth for over 4 billion years. Every aspect of our biology, from our cardiovascular and musculoskeletal systems to the very structure of our DNA, is tailored to the resistance of gravity. When our bodies follow space-time geodesics called orbits, these systems unravel. Feustel's experience is not an isolated case. Scott Kelly, another NASA astronaut, spent 340 days aboard the International Space Station in a mission spanning from 2015 to 2016. He returned with a litany of physiological changes: a 7% loss in body mass, elongated spine, muscle atrophy and fluid redistribution that caused vision problems. Even after rigorous exercise regimens designed to mitigate these effects, astronauts' bodies require years to recover — and some changes are irreversible.

These are glaring indicators that we humans are fundamentally unfit for environments beyond Earth. Yet, space agencies continue pouring billions into trying to equip our Earth-evolved biology for extraterrestrial survival. This endeavor is like trying to create a self-sustaining fish tank, one that doesn't require cleaning or other help from outside. It is worth noting that we have failed to create the human equivalent of such a tank on Earth, a planet perfectly suited to our species. Biosphere 2, the infamous 1990s experiment in the Arizona desert, lasted its planned two years but required external intervention to address oxygen depletion and other challenges, proving how complex and delicate life-support systems truly are.

Moriba Jah is an astrodynamicist, space environmentalist and professor of aerospace engineering and engineering mechanics at the University of Texas at Austin. An AIAA fellow and MacArthur fellow, he's also chief scientist of startup Privateer.

The more recent Crew Health and Performance Exploration Analog mission, or CHAPEA, completed last July at NASA's Johnson Space Center in Houston, focused on psychological isolation and plant growth in a simulated Martian habitat. However, it did not test the challenges of living in low gravity or attempt a fully closed ecological system. While CHAPEA provided valuable insights, it did not overcome the fundamental ecological and physiological challenges that plagued Biosphere 2.

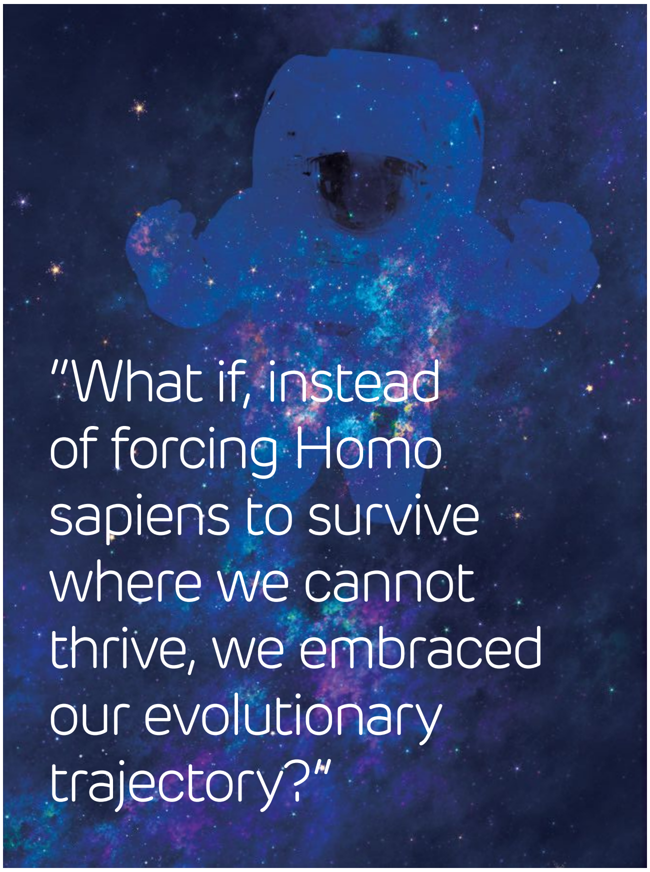
The misguided obsession with equipping humans to survive forever on other worlds ignores an essential truth: Homo sapiens are not the pinnacle of biological development but a chapter in a much longer story. Evolution is ongoing, and extinction is inevitable for every species. The fossil record shows us this repeatedly. Why should we assume we are the exception?

What if, instead of forcing Homo sapiens to survive where we cannot thrive, we embraced our evolutionary trajectory? As I first wrote about in a 2023 column, we would be better off focusing on the development of a next-generation hominid species that I call Homo machina. This synthesis of Homo sapiens and machines may sound like science fiction, but it's not centuries away. The first work could begin now. I propose a NASA program of record to fund research and development into human-machine synthesis, focusing on the specific challenges of free-fall environments. Initial milestones could include mechanically augmented systems for astronauts within a decade and fully integrated Homo machina prototypes within 50 years. This transition would be gradual but deliberate, leveraging advancements in artificial intelligence, robotics and biotechnology to create a species that can thrive where Homo sapiens cannot.

The physiological challenges faced by astronauts like Feustel and Kelly should compel the space community to urge reconsideration of the massive investments being funneled into life support techniques for survival on Mars, a theme that seems likely to persist in the era of Elon Musk and President Donald Trump.

Homo machina could transform our approach to space exploration. Replacing our flesh and blood with mechanically augmented limbs, for example, could mitigate muscle wasting and bone loss in free-fall environments. Artificial circulatory systems might prevent fluid redistribution that impairs vision. Reproductive systems could be redesigned or supported by advanced biotechnologies to ensure species continuity in space. This isn't about patchwork fixes; it's about reengineering what it means to be human in a way that aligns with the challenges of extraterrestrial environments.

Critics may balk at the idea, citing ethical and philosophical concerns about "tampering" with human biology. These concerns are not without merit but are ultimately shortsighted. Technology has always been an extension of evolution. From the first stone tools to gene editing, we have continually reshaped our relationship with the natural world. We are not separate from the environment or nature. We're an integral part of it. Homo machina would be the logical next step in this progression — a species designed not to dominate Earth but to peacefully explore and thrive in the universe.



Consider Mars. If you weigh 100 kilograms on Earth, you'll weigh only 38 kg there. The atmosphere is thin, there is no global magnetic field, and air temperatures swing wildly from 28 degrees Celsius to minus 75 degrees . It's a death trap for Earth-adapted organisms. Terraforming is a pipe dream requiring millennia, if it is even possible. Why waste resources on such futile pursuits when we could channel them into understanding the impacts of space on Earth-evolved life-forms and preparing for an evolutionary future?

Space exploration is not without merit, but we must be clear-eyed about the biological challenges. Every experiment aboard ISS that documents muscle atrophy, bone loss and fluid shifts is not just data; it is Gaia saying, "I'm your home." Rather than fighting it, we should learn from it. For some, space exploration is an escapist fantasy, a desire to flee Earth because of how badly we've treated it. If you're keen on taking your one-way trip, please proceed and enjoy.

The path forward is not to abandon space exploration but to reframe it. Let us study the limits of Homo sapiens in extreme environments, not to overcome them artificially but to inform the creation of Homo machina. Our species will not last forever, but the dream of exploring the universe need not perish with us. By relinquishing our anthropocentric hubris and embracing the potential of Homo machina, we can secure a future in which the stars are within our grasp. ★

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1925

Feb. 2 U.S. President Calvin Coolidge signs the Contract Air Mail Act, permitting the Post Office Department to enlist private airlines to carry air mail. The legislation, also known as the Kelly Act, greatly stimulates the growth of commercial aviation in the United States. NASA, **Aeronautics and Astronautics 1915-1960**, p. 19.

Feb. 4 German pilot Richard Wagner and Italian pilot and aeronautical engineer Guido Guidi break 20 world records in an all-metal Dornier Wal plane powered by two Rolls-Royce engines. Among the records: reaching a speed of 168.52 kph over a 500-kilometer closed circuit with a 1,500-kilogram payload; and reaching an altitude of 3,006 meters with a 2,000 kg payload. **The Aeroplane**, March 25, 1925, p. 282.

Feb. 6 Curtiss pilot M.M. Merrill completes the first flight of a single-piece magnesium propeller at Curtiss Field, New York. The tests, for which the propeller is fitted to a Standard J1 trainer, show “promising performance.” The alloy has a density 25% less than duralumin. **Aviation**, March 2, 1925, p. 248.

Feb. 27 The 1924 Collier and Mackay Army Trophies are presented to the U.S. Air Service and to individual fliers Capt. Lowell H. Smith, 1st Lts. Leigh Wade, Eric Nelson and Leslie Arnold, and 2nd Lts. Henry Ogden and John Harding for their 1924 around-the-world flight. **National Aeronautic Association Review**, April 1925, p. 62.

1950

1 **Feb. 7** U.S. Navy Cmdr. Thomas Robinson demonstrates the long-range capabilities of the Lockheed P2V-3C Neptune patrol bomber. After taking off from the USS Franklin D. Roosevelt carrier, located off the coast of Jacksonville, Florida, he flies some 8,000 kilometers to San Francisco by way of the Bahamas, Panama Canal, the west coast of Central America and Mexico. The 25-hour, 59-minute journey is the longest nonstop flight to date from a carrier. **U.S. Naval Aviation. 1910-1970**, p. 181; **Aircraft Yearbook, 1950**, p. 341.

2 **Feb. 21** The first de Havilland DH106 Comet prototype completes its longest endurance flight yet. The Comet takes off from the company’s plant in Hatfield in Hertfordshire, England, and remains aloft 5 hours, 45 minutes. The aircraft reaches an altitude of 41,500 feet, just over its most economical cruising altitude. **Flight**, March 1950, p. 181; **The Aeroplane**, March 3, 1950, p. 247.

Feb. 22 The British Overseas Airways Corp. takes delivery of its first Handley Page Hermes IV transport, powered by four air-cooled Bristol Hercules 763 radial piston engines. The airliner begins ferrying passengers in August on BOAC’s South and East African routes, replacing Short Solents and Avro Yorks. **Flight**, March 2, 1950, p. 280.

1975

Feb. 4 The U.S. Air Force Systems Command’s Aeronautical Systems Division announces plans to evaluate fan blades constructed from an aluminum alloy matrix reinforced by silicon carbide-coated boron filaments. The blades will be flown on a Grumman F-111 Tiger, a supersonic, single-seat fighter, by the Air Force Flight Test Center in California for two to three years. At 40% lighter than conventional titanium blades, the composite ones could increase operating efficiency and tip speeds. NASA, **Astronautics and Aeronautics, 1975**, p. 24.

3 **Feb. 4** Scientist Anatoly Blagonravov, one of the architects of the Soviet Union’s space program, dies in Moscow at 80. As chairman of the Soviet Academy of Sciences’ Commission for Space Research, he played a leading role in the development and launch of Sputnik 1, the world’s first artificial satellite. He began his career in the military, mainly in the area of automatic infantry weapons, and later turned to the development of spacecraft. He later represented the Soviet Union on the United Nations Committee on the Peaceful Uses of Outer Space and, with his counterparts at NASA, negotiated the agreement that led to the 1975 docking of an Apollo and Soyuz craft in orbit. **New York Times**, Feb. 6, 1975, p. 34.

Feb 6 NOAA’s SMS-2, the Synchronous Meteorological Satellite 2, is launched by a three-stage Thor-Delta rocket. The 628-kilogram cylindrical satellite carries five instruments to measure proton, electron and solar X-ray fluxes, among other purposes. SMS-2 is the second in a series of operational prototypes built by NASA to demonstrate technology for NOAA’s future constellation, Geostationary Operational Environmental Satellite, or GOES. **NASA Press Releases,** 75-6 and 75-27.

4 **Feb. 6** France’s Starlette passive geodetic satellite is launched from Kourou, French Guiana, to study Earth’s gravitational field and elasticity. **Aviation Week**, Dec. 9, 1975, p. 55.

Feb. 12 For the first time, water vapor was detected deep in Jupiter’s atmosphere, NASA’s Ames Research Center announces. The discovery was made by University of Arizona scientists aboard NASA’s Airborne Infrared Observatory, a modified Lockheed C-141 Starlifter aircraft, with a newly installed 91.5-centimeter infrared telescope. That data, combined with information gathered by the Pioneer 10 and 11 probes, adds to speculation that the red, orange and brown coloring of Jupiter’s clouds might be attributed to presence of organic compounds. **Astrophysical Journal,** May 1, 1975, pps. L137-140.

Feb. 14 The government of Indonesia awards Hughes Aircraft Corp. a $23.6 million contract to build a satellite communications system comprising two satellites, a control station in Jakarta and nine ground stations. An additional 30 stations are to be constructed throughout the Indonesian islands by additional companies. NASA, **Astronautics and Aeronautics, 1975**, p. 31.

Feb. 15 The U.S. could land men on Mars in 10 years if NASA were to make a commitment equivalent to former President Kennedy’s 1961 moon landing pledge, rocket pioneer and former NASA official Wernher von Braun says in a speech at the Johns Hopkins University Applied Physics Laboratory. He estimates that a Mars program would cost roughly the same as the $25 billion Apollo moon program. **Baltimore Sun**, Feb. 16, 1975, p. B16.

Feb. 19 Hairline cracks are discovered in fittings of two of the fins of the Saturn IB rocket that is scheduled to launch the Apollo spacecraft in July for the Apollo-Soyuz Test Project. Cracks are later found in the remaining six fins, and NASA engineers in March begin installing new fins and reinforcing the surrounding areas. **NASA Release** 75-50 and 75-57.

Feb. 26 NASA announces a memorandum of understanding with Zaire to build the first African ground station that will receive data from the Landsat 1 and 2 satellites. According to a press release, the station “would produce both computer tapes and photographic imagery that would include data on the African continent from Chad to South Africa and from Kenya to the Ivory Coast.” **NASA Release** 75-73.

Feb. 28 The preliminary design review of Space Shuttle Orbiter 102, later designated Columbia, is completed on schedule, NASA announces. NASA, **Astronautics and Aeronautics, 1975**, p. 238.

2000

5 **Feb. 11** French aviator Jacqueline Marie-Thérèse Suzanne Douet, the second woman to break the sound barrier, dies in Paris at 82. She set five air speed

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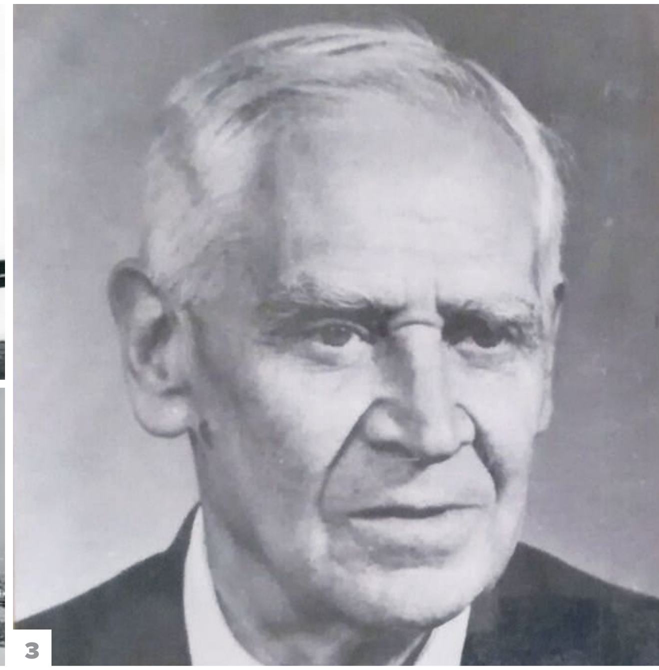

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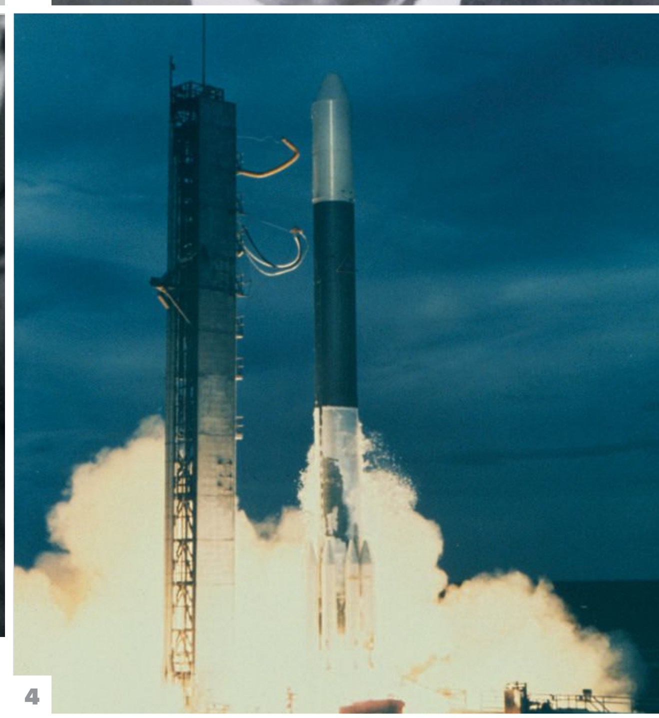

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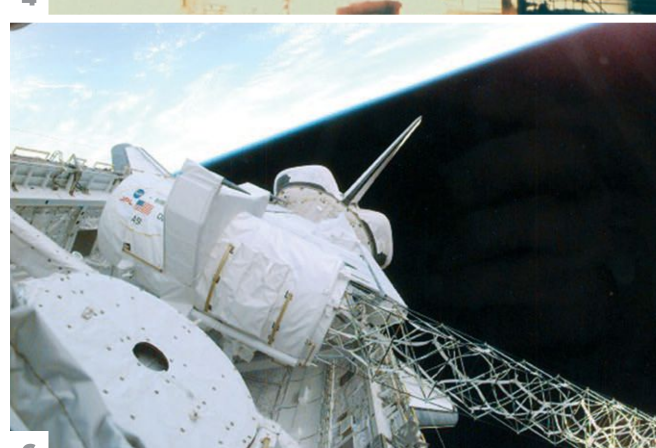

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records for women in the 1950s and '60s, the last in June 1963 when she reached 2,038.7 kph in a Dassault Mirage IIIR over a 100-kilometer closed circuit. **New York Times**, Feb. 17, 2000, p. 25.

6 **Feb. 11** NASA's space shuttle Endeavour is launched for an 11-day flight, its last without docking to the International Space Station. The primary objective is to deploy the Shuttle Radar Topography radar instrument, designed to take high-resolution three-dimensional maps of most of Earth at the rate of 100,000 square kilometers a minute. The instrument's 60-meter-call receiver mast is the largest single structure yet deployed in space. **Aviation Week**, Feb. 21, 2000, pp. 45-46.

Feb. 11 Low-cost airline JetBlue Airways begins passenger operations, with service between JFK International Airport in New York and Fort Lauderdale, Florida. **JetBlue release** via Business Wire, Feb. 11, 2020.

Feb. 14 NASA's NEAR spacecraft, short for Near Earth Asteroid Rendezvous, enters orbit around Eros, becoming the first spacecraft to orbit an asteroid. NEAR sends back close up photos. **Aviation Week**, Feb. 21, 2000, p. 51.

LOOKING BACK

COMPILED BY FRANK H. WINTER and ROBERT VAN DER LINDEN

1925

1 **March 10** U.S. Navy Rear Adm. William Moffett is appointed for a second tour as chief of the Navy's Bureau of Aeronautics. Bureau chiefs usually serve only one tour, but an exception is made for Moffett because the naval bureau, created in 1921 by Congress, is still being established. **Aviation**, March 23, 1925, p. 325.

March 18 British pilot Alan Cobham arrives at Croydon Airport, London, completing a 27,000-kilometer round trip to India made in 220 hours of flying time. Cobham had left Croydon in November in a 50-passenger de Havilland biplane, accompanied by Air Vice-Marshal Sir Sefton Brancker, British director of civil aviation, and engineer A. B. Elliot. During the trip, Brancker surveys possible locations for airports in India. **Flight**, March 26, 1925, pp. 180-188.

Also in March The U.S. Navy conducts Fleet Problem V, the first exercise to incorporate aircraft carrier operations. For this scenario, an attack on the Hawaiian Islands, aircraft take off from the USS Langley off the California coast to scout ahead of the invading force. Their performance convinces U.S. Fleet Commander in Chief Adm. Robert Coontz to recommend speeding the completion of the USS Lexington and Saratoga carriers as soon as possible and improving the Langley's catapult and recovery gear. **United States Naval Aviation 1910-1970**, p. 57.

1950

2 **March 1** Boeing completes the first production B-47A Stratojet bomber and turns it over to the U.S. Air Force for engineering inspection prior to its final delivery. After entering service, the B-47A becomes one of the mainstays of Strategic Air Command, alongside the Convair B-36 and, later, the Boeing B-52. Aviation Week, March 20, 1950, p. 7; **Aircraft Yearbook, 1950**, p. 342.

March 14 Chance Vought test pilot Paul Thayer completes the inaugural flight of the first production Vought F7U-1 Cutlass from Hensley Field, near Dallas. A twin-fin, twin-engine, carrier-based aircraft, the Cutlass is the first tailess fighter produced in the United States. It is powered by two Westinghouse turbojets with afterburners and is armed with four 20-millimeter cannons. **Aircraft Yearbook, 1950**, p. 342.

March 15 The Joint Chiefs of Staff decide to transfer all authority for strategic long-range guided-missile development to the U.S. Air Force. The decision follows the final report by Assistant Secretary of the Air Force Harold Stuart for the Committee on Guided Missiles of the Research and Development Board. **Aviation Week**, March 6, 1950, pp. 12-13.

March 16 As part of its ongoing flight tests, the first de Havilland DH106 Comet flies to Rome, piloted by John Cunningham and Peter Bugge and carrying 11 passengers. The aircraft takes off from the de Havilland plant in Hatfield, outside London, and lands at Ciampino Airport in 2 hours, 2 minutes, 52 seconds. **The Aeroplane**, March 24, 1950, p. 333.

1975

March 3 As part of NASA's Global Atmospheric Sampling Program, or GASP, a second instrumented Boeing 747 begins sampling flights to monitor pollution in Earth's upper atmosphere. GASP measurements of carbon dioxide, ozone and water vapor help scientists detect changes in the amount of ozone and determine whether vapor trails from jets are contributing to the cloud cover and the amount of pollution caused by aircraft. **NASA Release** 75-60.

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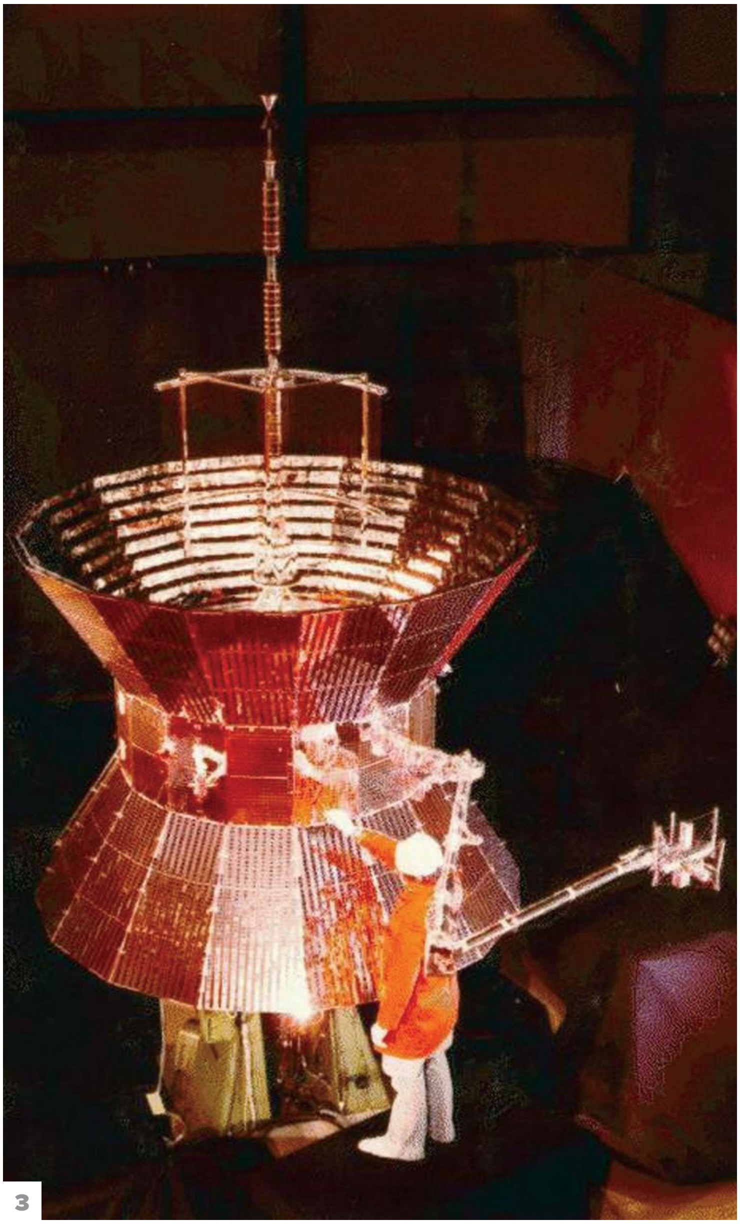

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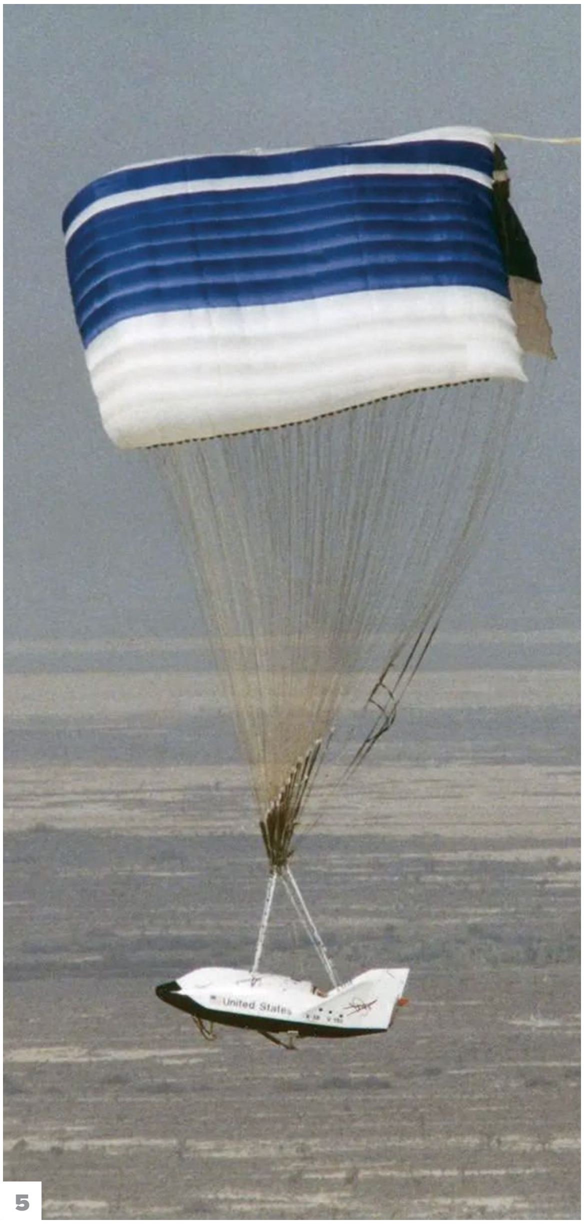

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March 4 The first production model of the Soviet Union's Tu-144 supersonic transport makes its inaugural flight from Moscow to Alma-Ata, the capital of the Kazakh Republic in South Central Asia. The aircraft, designed by Aleksy Tupolev, travels almost 4,000 kilometers in just over 90 minutes, reaching an altitude of 17,400 miles. NASA, **Aeronautics and Astronautics, 1975**, p. 44.

3 **March 15** Helios 1, the U.S.-West German solar probe launched in December, makes the closest approach to the sun of any human-made object. Traveling at 238,000 kph, Helios 1 from a distance of 47 million kilometers measures the solar wind, magnetic fields, solar and galactic cosmic rays, electromagnetic waves, micrometeoroids and zodiacal light. NASA, **Aeronautics and Astronautics, 1975**, p. 46.

March 16 NASA's Mariner 10 makes its final and closest flyby of Mercury, at a distance of 327 kilometers. The spacecraft returns about 300 TV pictures of the planet's surface, as well as measurements confirming that Mercury has an intrinsic, or natural, magnetic field. **Aviation Week**, March 24, 1975, pp. 24-25.

4 **March 17** Vanguard 1, the oldest satellite still in orbit, completes its 17th year in space. [Related story on page 9.] The 1.5-kilogram solar-powered spacecraft has circled the Earth some 67,000 times since its launch in 1958. The satellite was the fourth to orbit Earth, following two Soviet satellites and the first U.S. satellite, Explorer 1. **Los Angeles Times**, March 18, 1975.

March 19 NASA announces that it will loan out slices of lunar samples gathered during Apollo lunar landings to colleges and universities offering undergraduate or graduate courses in the geosciences. **NASA Release** 75-76.

2000

March 4 Beal Aerospace test fires its BA-810 engine at its McGregor, Texas, facility. The design, which uses a hydrogen peroxide as the oxidizer and kerosene as fuel, is the second most powerful liquid-fuel engine built since the F-1 that powered NASA's Saturn V rockets. The BA-810. **Aviation Week**, March 13, 2000, p. 36.

March 13 The U.S. Navy opens its first permanent hangar built specifically for unoccupied aerial vehicles at the Webster Field annex near Patuxent River Naval Air Station in Maryland. **United States Naval Aviation 1910-2010**, p. 533.

5 **March 30** Engineers at NASA's Dryden Flight Research Center in California test a prototype of the X-38 Crew Return Vehicle. After being released from its B-52 carrier aircraft at an altitude of 39,000 feet, the X-38 opens its parachute and touches down in a nearby lake bed. This "flying lifeboat" is being developed as a low-cost alternative to the shuttle orbiters for ferrying astronauts to and from the International Space Station. NASA, **Astronautics and Aeronautics: A Chronology, 1996-2000**, p. 257.

Email us at aeropuzzler@aerospaceamerica.org

Drip, drop

Q: It's supposed to rain heavily all day. You decide to pass the time binging "Manifest." You have a choice of watching via a Ka-band satellite link, Ku-band or X-band, now temporarily available through a special government program. Explain the physics of rain drops and radio waves that define the best choice.

SEND A RESPONSE OF UP TO 250 WORDS
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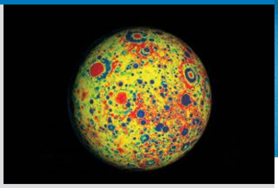
FROM THE JANUARY ISSUE



DOES MASS MATTER TO MEASURE MASS:

We asked you whether the two spacecraft that carried out NASA's Gravity Recovery and Interior Laboratory mission had to have the same mass to measure variations in lunar gravity. Here is the winning response and a note from scientist Michael Watkins, who co-conceived the concept behind GRAIL.

WINNER They do not need to have the same mass to do their job. Each spacecraft's response to variations in lunar gravity arises from the acceleration each spacecraft experiences in consequence of lunar gravity. The equation for the acceleration of a spacecraft due to a celestial body's gravity does not contain the mass of the spacecraft itself because it divides out.**

Brent W. Barbee, AIAA senior member
Gaithersburg, Maryland
Brent is the lead planetary defense applications scientist at NASA's Goddard Space Flight Center in Maryland, and an adjunct faculty member at the University of Maryland.

***The reference to "dividing out" is another way of saying that the mass of the two satellites was very small compared to the mass of the moon, so that the effect of gravity on each was essentially the same regardless of the precise mass of each. Aside from gravity, though, the satellite's motions were also affected by non-gravitational forces like solar radiation pressure, which is sensitive to the area to mass ratio. And of course, it is generally less expensive to build two nearly identical spacecraft than two very different ones. So, in the end, the spacecraft were close in mass, but not really due to gravitational effects. — Michael Watkins*

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